THE EFFECTS OF THREE METHODS OF INSTRUCTION ON

ACHIEVEMENT AND ATTITUDES IN GENERAL

COLLEGE MATHEMATICS

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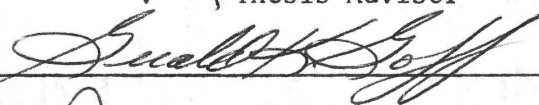# THE EFFECTS OF THREE METHODS OF INSTRUCTION ON

# ACHIEVEMENT AND ATTITUDES IN GENERAL

# COLLEGE MATHEMATICS

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# PREFACE

The purpose of this study was to investigate the modification of
attitudes toward mathematics and resulting achievement in mathematics
of Math 1314 students who were divided into three groups, each group re-
ceiving a different treatment.

Special gratitude is given to Dr. Douglas B. Aichele, who served
as Chairman of my advisory committee, and who offered much guidance
throughout my years at Oklahoma State University. I am also grateful
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Special thanks goes to all of the people that had a part in pro-
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debt to my wife, Judith, and my daughter, Tanya, for their sacrifices
and for providing the encouragement that made this possible.

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CHAPTER I

INTRODUCTION

General College Mathematics, Math 1314, is taught at Oklahoma
State University basically for non-mathematics, non-science majors and
regarded as fulfilling the mathematics requirement for general educa-
tion.  Typically, students have had little previous mathematics back-
ground and exhibit less desire to remedy these mathematics deficiencies.
These characteristics make it impossible to initiate very deep dis-
cussions of theoretical mathematics or complicated algorithmic process-
es as possible alternatives for a course of study for Math 1314.

Therefore, one possible goal for Math 1314 is to emphasize the
aesthetic beauty of mathematics.  This goal is in keeping with the
general philosophy of courses taught in conjunction with the Arts and
Sciences curriculum, to which Math 1314 belongs.  This goal, of course,
includes treating mathematics as a pattern of thought, a logical
structure that exists with assumptions and within constraints.

With this possible goal in mind, one must consider alternate ways
of measuring success in attaining that goal.  The nature of the goal and
the nature of the student enrolled in Math 1314 perhaps suggest that
measurement in the affective domain would be more appropriate.  If so,
then methods that enhance objectives of the affective domain should also
be considered, and would include any method that would relieve the
anxieties of the students when asked to perform in mathematics class.

Future classes of Math 1314 should be aided by as much information

as possible, including information that concerns the goals and methods of instruction mentioned above.

## Statement of the Problem

Recently more emphasis has been placed upon measurement in the affective domain; as a result, the assessment of attitudes is considered an important function of education. To some extent, it is now accepted that what a person is or may become, whether he succeeds or fails, whether he approaches his potential or allows his talents to be underdeveloped, depends upon the attitudes that person has acquired and the view he has of himself with respect to his environment. This emphasis on attitudes is as important in mathematics as it is in any other discipline. There is also evidence that individuals scoring high on mathematical attitude scales tend to be more socially and intellectually mature, more self-controlled, and have more theoretical interests than individuals scoring low on the scales (4).

The improvement of attitudes, if such a thing can be accomplished, is always worthy of attainment in educational realms, especially if at the same time there is evidence of improvement in achievement. A more eloquent point was made by Anatole France in 1918 as he said:

> It is only by amusing oneself that one can learn.
> The whole art of teaching is only the art of awakening the
> natural curiosity of young minds for the purpose of satis-
> fying it afterwards; and curiosity itself can be vivid and
> wholesome only in proportion as the mind is contented and
> happy. Those acquirements crammed by force into the minds
> of children simply clog and stifle intelligence. In order
> that knowledge be properly digested, it must have been
> swallowed with a good appetite (26, p. 198).

The emphasis on attitudes is not to imply that the importance of achievement is to be lessened. Our very societal structure places

priorities on achievement; hence, maintaining a proper level of achievement is also a major task of any instructional system in mathematics. However, the assessment of attitudes toward mathematics would clearly be of less concern if attitudes were not thought to affect performance in some way. We note that this relationship is one of reciprocity in that achievement also will probably affect attitudes (56).

Specifically, the objectives of this research are to answer the following questions:

A.  Which of three methods of teaching Math 1314 is significantly better with respect to modifying achievement?

B.  Which of three methods of teaching Math 1314 is significantly better with respect to modifying attitudes toward mathematics (general)?

C.  Does Math 1314 contribute to changes in students' attitudes toward mathematics (general)?

D.  Does Math 1314 contribute to changes in students' attitudes toward each of the following areas related to mathematics: (1) the learning of mathematics, (2) mathematics as a process, (3) the place of mathematics in society, and (4) school and learning generally?

E.  Which of three methods of teaching Math 1314 is significantly better with respect to modifying students' attitudes toward each of the following: (1) the learning of mathematics, (2) mathematics as a process, (3) the place of mathematics in society, and (4) school and learning generally?

## Hypotheses

The hypotheses are arranged according to the five areas described in the preceding section. For purposes of statistical treatment, the hypotheses are reported in the null form.

A. $H_1$: There is no significant difference between method used in the discussion sections and resulting achievement of students enrolled in Math 1314.

B. $H_2$: There is no significant difference between method used in the discussion sections and resulting attitudes toward mathematics (general) of the students enrolled in Math 1314.

C. $H_3$: There is no significant difference between initial attitudes of students in Group $E_1$ toward mathematics (general) and terminal attitudes of students in Group $E_1$ toward mathematics (general).

$H_4$: There is no significant difference between initial attitudes of students in Group $E_2$ toward mathematics (general) and terminal attitudes of students in Group $E_2$ toward mathematics (general).

$H_5$: There is no significant difference between initial attitudes of students in Group C toward mathematics (general) and terminal attitudes of students in Group C toward mathematics (general).

$H_6$: There is no significant difference between initial attitudes of students enrolled in Math 1314 toward mathematics (general) and terminal attitudes of students enrolled in Math 1314 toward mathematics (general).

D. $H_7$: There is no significant difference between initial attitudes of students in Group $E_1$ concerning the learning of mathematics and terminal attitudes of students in Group $E_1$ concerning the learning of mathematics.

$H_8$: There is no significant difference between initial attitudes of students in Group $E_2$ concerning the learning of mathematics and terminal attitudes of students in Group $E_2$ concerning the learning of mathematics.

$H_9$: There is no significant difference between initial attitudes of students in Group C concerning the learning of mathematics and terminal attitudes of students in Group C concerning the learning of mathematics.

$H_{10}$: There is no significant difference between initial attitudes of students enrolled in Math 1314 concerning the learning of mathematics and terminal attitudes of students enrolled in Math 1314 concerning the learning of mathematics.

$H_{11}$: There is no significant difference between initial attitudes of students in Group $E_1$ concerning mathematics as a process and terminal attitudes of students in Group $E_1$ concerning mathematics as a process.

$H_{12}$: There is no significant difference between initial attitudes of students in Group $E_2$ concerning mathematics as a process and terminal attitudes of students in Group $E_2$ concerning mathematics as a process.

$H_{13}$: There is no significant difference between initial attitudes of students in Group C concerning mathematics as a process and terminal attitudes of students in Group C concerning mathematics as a process.

$H_{14}$: There is no significant difference between initial attitudes of students enrolled in Math 1314 concerning mathematics as a process and terminal attitudes of students enrolled in Math 1314 concerning mathematics as a process.

$H_{15}$: There is no significant difference between initial attitudes of students in Group $E_1$ concerning the place of mathematics in society and terminal attitudes of students in Group $E_1$ concerning the place of mathematics in society.

$H_{16}$: There is no significant difference between initial attitudes of students in Group $E_2$ concerning the place of mathematics in society and terminal attitudes of students in Group $E_2$ concerning the place of mathematics in society.

$H_{17}$: There is no significant difference between initial attitudes of students in Group C concerning the place of mathematics in society and terminal attitudes of students in Group C concerning the place of mathematics in society.

$H_{18}$: There is no significant difference between initial attitudes of students enrolled in Math 1314 concerning the place of mathematics in society and terminal attitudes of students enrolled in Math 1314 concerning the place of mathematics in society.

$H_{19}$: There is no significant difference between initial attitudes of students in Group $E_1$ concerning school and learning generally and terminal attitudes of students in Group $E_1$ concerning school and learning generally.

$H_{20}$: There is no significant difference between initial attitudes of students in Group $E_2$ concerning school and learning generally and terminal attitudes of students in Group $E_2$ concerning school and learning generally.

$H_{21}$: There is no significant difference between initial attitudes of students in Group C concerning school and learning generally and terminal attitudes of students in Group C concerning school and learning generally.

$H_{22}$: There is no significant difference between initial attitudes of students enrolled in Math 1314 concerning school and learning generally and terminal attitudes of students enrolled in Math 1314 concerning school and learning generally.

E. $H_{23}$: There is no significant difference between method used in the discussion sections and resulting attitudes of students toward the learning of mathematics.

$H_{24}$: There is no significant difference between method used in the discussion sections and resulting attitudes of students toward mathematics as a process.

$H_{25}$: There is no significant difference between method used in the discussion sections and resulting attitudes of students toward the place of mathematics in society.

$H_{26}$: There is no significant difference between method used in the discussion sections and resulting attitudes of students toward school and learning generally.

## Importance of the Study

Although the National Council of Teachers of Mathematics has published its views concerning the competencies and skills essential for enlightened citizens (55), the mathematical knowledge that the students enrolled in Math 1314 will need in the next ten to fifty years is not universally agreed upon. However, citizens in future years should logically and judiciously be able to cope with the increasing amount of statistics, facts and figures being used, and should recognize the role of mathematics in making more responsible and self-reliant judgments (55). Viewing mathematics in light of Jerome Bruner, i.e., treating it as a process, perhaps the best that can be done with respect to Math 1314 students is to have these students develop a positive attitude toward mathematics. Thus, an evaluation of attitudes is justifiable and important, and keeps in line with the old Chinese proverb--a past not forgotten is a guide to the future (62).

The study of attitudes occupies a central place in social-psychological research. Knowledge of attitudes and their functioning is of interest both theoretically and practically. No theory of social

behavior can be complete without incorporating attitude functioning, and it is doubtful that social behavior can be predicted without some knowledge of attitudes.

Attitude improvement has a long history. About the middle of the colonial period John Locke wrote that he "had a fancy that learning might be made a play and recreation to children" so that they would "desire to be taught" (32, p. 18). Attitudes may be by-products of the socialization process, and as such, significantly influence man's responses to cultural products and to other people. If the attitude of a person toward a given object, or class of objects, is known, it can be used in conjunction with situational and other variables to predict and explain reactions of the person to that class of objects. Hence, to the extent that relationships governing the change of attitudes are known, they may be used to manipulate the individual's reactions to relevant objects, e.g., psychotherapy, education, and propaganda. It is not surprising, then, that study of attitudes has occupied a central place in social psychology during the past fifty years.

It is becoming increasingly clear that training in the mathematical sciences is a key to continuance of scientific and technological progress. As a result, various projects for the improvement of teaching mathematics have been established throughout the country. These projects, however, have concentrated mainly on the rewriting of textbook material, while only a few (Robert Davis, etc.) have considered the psychology of learning. Thus, the contributions which psychology can make to the improvement of mathematics teaching have not as yet been fully explored.

The concept of attitude has long been mentioned in conjunction with philosophies of education and, indeed, it is also emphasized in the very nature of man. As Kelley and Rasey point out, "The task of the teacher is to facilitate growth, particularly in the areas of attitude, habit, and knowledge (39, p. 77)." It is sometimes forgotten that in addition to learning principles, facts, and methods in school, children also learn attitudes, values, and appreciations, and, it is hoped they develop a desire for further learning. Terms such as attitude, value, and appreciation refer to affective objectives of instruction; objectives that should constitute a part of learning every school subject. While it is not appropriate to discuss completely the goals of higher education here, it is important to note that attitudinal and emotional changes as well as more obvious cognitive goals such as critical thinking and broad knowledge are included. In evaluation of the effectiveness of college instruction we need to consider not only the accumulation of knowledge but the development of problem-solving skills and desirable attitudes as well.

Reeve (61) has voiced the idea that the educational institutions of our society have shown concern over the knowledge, skills, emotional life and cultural values of students. Thus, researchers, school people, and especially teachers are interested in the nature of attitudes. That is, how attitudes are acquired, developed or modified, and the degree to which they are related to anticipated pupil achievement as well as to the application of subject matter. Thus, it is appropriate that the affective goals of mathematics instruction be the goals that are represented by Objective VI of the National Assessment of Educational Progress Mathematics Objectives:

VI.    Appreciation and use of mathematics.

A.    Recognizing the importance and relevance of mathematics to the individual and to society.

From age 9 and up, there should be a recognition of the importance and relevance of mathematics to the individual and to society.  This subobjective (VI. A.) does not necessarily involve enjoyment of mathematics or participation in the development of ideas, but rather it focuses on the acceptance of mathematics as being worthwhile--i.e., the individual recognizes that mathematics is necessary whether or not he uses it or enjoys studying it.  For example, the individual should recognize the contribution that mathematics has made to the progress of civilization, especially in the sciences.  There should also be appreciation of the elegance, economy, and techniques of mathematics. Of course, the level of sophistication of such appreciations should increase with age; nevertheless, some manifestation of these attitudes should appear at all age levels.

B.    Enjoyment of mathematics.

In addition to having an appreciation for the importance of mathematics, the individual should also enjoy the subject and its specialized techniques (e.g., using compasses and working with numbers).  Emphasis should be placed on the enjoyment involved in acquiring a knowledge of mathematics and in the satisfaction gained from using it rather than on the amount that is learned. The corollary of this is also important--i.e., the individual should not hate or fear mathematics.  These attitudinal goals are especially important during the school years since they are likely to influence how much mathematics an individual is willing to study, and therefore, have at his disposal.

C.    Using the content and techniques of mathematics.

When the mathematics is relevant and appropriate, individuals should use what they have learned.  Because the amount of knowledge varies with age level, evidence of a willingness to use mathematics will take difference forms at different age levels.

D.    Participation in the learning of mathematics beyond that which is merely required, and actively seeking to further personal development in the area of mathematics.

The fourth subgoal relates to the individual's

development of a curiosity about mathematics as
well as a readiness to engage in activities in
this area (i.e., independent of school and/or job
assignments). In contrast to the objectives in
other categories, independent action rather than
reaction is stressed. This goal emphasizes that
the individual should actively seek participation
and further development of his skills in mathe-
matics (as indicated by such things as reading about
"new" math and tackling strange looking problems).
This is opposed to merely passing judgment or using
the principles learned when this was required. It
is expected that such interests will not develop
before the age of 13; however, once developed, they
will probably carry through into adult life (54,
p. 29-30).

Unless the efforts of the colleges and universities to educate

people have been a total failure, one would be hard pressed to accept

the first sentence of the statement below that is attribed to

G. H. Hardy:

It would be difficult now to find an educated man quite
insenstive to the aesthetic appeal of mathematics. It may
be very hard to define mathematical beauty, but that is
just as true of beauty of any kind--we may not know quite
what we mean by a beautiful poem, but that does not prevent
us from recognizing one when we read it (35, p. 25).

In opposition to this, the author feels that not only are many people

insensitive to the aesthetic appeal of mathematics, but many people

fear the very word "mathematics". As Mitchell Lazarus points out:

In addition to being a serious problem in education,
mathophobia can be a significant handicap in ordinary
adult life. Nearly every important issue of the day--
ecology, inflation, poverty, education, defense, inter-
national trade, and food supplies, to name just a few--
has a strong mathematical component. But beyond this,
mathematics is very much in the spirit of the times.
It takes part in almost all phases of human activity,
both intellectual and practical, besides serving as a
bridge between two arenas. There are exciting changes
being wrought in our technology, our society, our culture,
our very way of thinking. Whether one wishes to be a
part of these changes, or merely to observe them intelli-
gently, mathematics is rapidly coming to be indispensable.
It is no exaggeration to say that our contemporary world

is built on a foundation of mathematics. Those who are
mathematically illiterate are barred from a view of its
inner workings, they can see only the surface (41, p. 12).

This is not to deny the importance of studying mathematics for
aesthetic purposes. In this regard, Lazarus continues:

But I have not yet mentioned one most important reason
for learning mathematics. It is this: If art is the
arrangement of parts into pleasing and meaningful whole,
then there is no other art with the scope and power of
mathematics. Inherent in mathematics is a particular
quality of beauty, a sense of harmony and "thusness"
immensely satisfying to the mind. This is the fascina-
tion of mathematics. This is what mathophobia takes
away (41, p. 12).

Accepting the hypothesis that aesthetic value and techniques of

mathematics are among the important reasons for teaching mathematics,

one curious conclusion, as expressed best by G. H. Hardy, emerges. He

claims:

. . .pure mathematics is on the whole distinctly more
useful than applied. A pure mathematician seems to
have the advantage on the practical as well as on the
aesthetic side. For what is useful above all is tech-
nique, and mathematical technique is taught mainly
through pure mathematics (35, p. 74).

If we accept Hobven's views concerning the importance of mathe-

matics,

. . .without a knowledge of mathematics, the grammar of
size and order, we cannot plan the rational society in
which there will be leisure for all and poverty for
none. . . (35, p. 76-77).

the importance of achievement in mathematics is self-evident, and hence,

this study is of importance to at least four segments of the Oklahoma

State University environment. First, this study is of importance to

the student. It is important whether the material presented in Math

1314 is considered relevant to the student enrolled, along with pro-

viding the student with the opportunity to try and fulfill the demands

as stated by Lazarus above. Second, this study is important to the Department of Mathematics at Oklahoma State University and the subsequent instructors of Math 1314. Being a large service department, the Department of Mathematics should desire to know if it serves the clientele it purports to serve. Third, this study is important to the designers of the criteria that includes Math 1314 in the curriculum. If Math 1314 does not perform its designated function, possibly it is of no value to the student, and should be omitted from the requirements. Fourth, this study is important to the Oklahoma Board of Regents and the Oklahoma State Legislature in their quest for accountability.

## Assumptions

It is assumed that there were differences among students with regard to whether a statement was considered favorable or unfavorable. An assumption is also made that students having highly favorable attitudes are more likely to agree with statements having highly favorable scale values than they are with statements that do not.

The results of the achievement tests are assumed to be reliable indices to a student's mathematical knowledge. The results of the Aiken Attitude Scale are assumed to be reliable indices to a student's attitude toward mathematics (general). The results on the various parts of the Aichele Attitude Scale are assumed to be reliable indices to a student's attitude toward the respective parts of the scale.

## Limitations

This study is limited to those students enrolled in Math 1314 during the Fall Semster of the 1974-75 academic year at the Oklahoma

State University who completed the initial Attitude Survey and the terminal Attitude Survey, and who completed the initial Achievement test and the terminal Achievement test. Furthermore, this study is limited to the extent to which assessed attitude reflects true attitude and assessed achievement represents true achievement for each of the students involved.

## Definition of Terms

The following definitions apply to this study:

Math 1314. This is a four semester-hour course offered by the Mathematics Department of Oklahoma State University and officially carries the name General College Mathematics. For this study, however, Math 1314 will be defined to be only that group of students enrolled in General College Mathematics for the Fall Semester of the academic year 1974-1975 at Oklahoma State University who provided the data for this study.

Experimental Group 1, $E_1$. One section of Math 1314 students who were taught by a method that required the presentation of one quiz per week, where that quiz score was used as input in determining each student's final grade. Feedback of quiz results to Group $E_1$ was delayed to the next discussion section.

Experimental Group 2, $E_2$. One section of Math 1314 students who were taught by a method that required the presentation of one quiz per week, where that quiz was evaluated as soon as possible, usually prior to the dismissal of class. The quiz score was not used as input in determining each student's grade.

Control Group, C. One section of Math 1314 students who were taught by a traditional method. This method used lectures, discussion,

assigned problems, homework to be graded, announced quizzes and a report on a special topic.

Attitude Survey. An instrument, divided into two sections, that was used to assess initial and terminal attitudes relating to mathematics of students enrolled in Math 1314.

Aiken Attitude Scale. A section of the Attitude Survey used to measure students' attitudes toward mathematics (general).

Aichele Attitude Scale. A section of the Attitude Survey used to measure students' attitudes toward, (1) the learning of mathematics, (2) mathematics as a process, (3) the place of mathematics in society, and (4) school and learning generally.

Attitude Toward Mathematics (General). Each students' attitude toward mathematics (general) was measured by the Aiken Attitude Scale. The initial presentation of this scale determined the student's initial attitude toward mathematics (general) and the terminal presentation of this scale determined the student's terminal attitude toward mathematics (general). The difference in score between each student's initial attitude toward mathematics (general) and terminal attitude toward mathematics (general) represented the student's change in attitude toward mathematics (general).

Attitude Toward the Learning of Mathematics. The attitude toward the learning of mathematics of each student was measured by the Aichele Attitude Scale, Part I. The initial presentation of this scale determined the student's initial attitude toward the learning of mathematics and the terminal presentation of this scale determined the student's terminal attitude toward the learning of mathematics. The difference in score between each student's initial attitude toward the

learning of mathematics and terminal attitude toward the learning of
mathematics represented the student's change in attitude toward the
learning of mathematics.

Attitude Toward Mathematics as a Process. The attitude toward
mathematics as a process of each student was measured by the Aichele
Attitude Scale, Part II. The initial presentation of this scale deter-
mined the student's initial attitude toward mathematics as a process
and the terminal presentation of this scale determined the student's
terminal attitude toward mathematics as a process. The difference in
score between each student's initial attitude toward mathematics as a
process and terminal attitude toward mathematics as a process repre-
sented the student's change in attitude toward mathematics as a process.

Attitude Toward the Place of Mathematics in Society. The atti-
tude toward the place of mathematics in society of each student was
measured by the Aichele Attitude Scale, Part III. The initial pre-
sentation of this scale determined the student's initial attitude
toward the place of mathematics in society and the terminal presenta-
tion of this scale determined the student's terminal attitude toward
the place of mathematics in society. The difference in score between
each student's initial attitude toward the place of mathematics in
society and terminal attitude toward the place of mathematics in soc-
iety represented the student's change in attitude toward the place of
mathematics in society.

Attitude Toward School and Learning Generally. The attitude
toward school and learning generally of each student was measured by
the Aichele Attitude Scale, Part IV. The initial presentation of this
scale determined the student's initial attitude toward school and
learning generally and the terminal presentation of this scale

determined the student's terminal attitude toward school and learning generally. The difference in score between each student's initial attitude toward school and learning generally and terminal attitude toward school and learning generally represented the student's change in attitude toward school and learning generally.

Achievement. Each student's mathematics achievement was measured by the instruments called the Structure of the Number System, Form A and Form B. Form A was given as a pretest and determined the student's initial mathematics achievement and Form B was given as a posttest and determined the student's terminal mathematics achievement. The gain score from initial achievement to terminal achievement for each student is defined to be the achievement for that student.

## Overview

This study is divided into five chapters, the first of which is devoted primarily to a statement of the problem under consideration. Several studies which are concerned directly and indirectly with attitudes and methods used to teach Math 1314 are discussed in Chapter II. The experiment is discussed in Chapter III and includes the design and sample, the measuring instruments, the collection of the data and the methods of analysis used in the treatment of the data. The complete findings are reported in Chapter IV, while Chapter V presents the overall summary, conclusions and implications and suggestions for further study.

CHAPTER II

REVIEW OF RELATED LITERATURE

Previously it was stated that among the purposes of this investigation were to:  (1) determine if the attitudes toward mathematics which are held by Math 1314 students are altered during the period of enrollment, (2) determine if any of three methods of teaching Math 1314 provides for greater achivement, and (3) determine if any of three methods of teaching Math 1314 provides for greater change in attitudes toward mathematics.  The purpose of this chapter is to present research studies that are directly or indirectly related to these purposes.

Attitudes

The majority of the studies reviewed emphasized that attitudes are modifiable.  There was a variety of sources which may be related to modification.  For example, movies, printed materials, oral arguments, and classroom instruction were used to substantiate the notion that attitudes can be changed.  The acceptance of the assumption that attitudes are alterable underlies this study.

Attitudes are learned, rather than being innate or a result of constitutional development and maturation (65).  Attitudes are learned through interaction with social objects and in social events or situations.  This being the case, attitudes demonstrate the same properties

as other learned reactions such as latency and threshold; and, they
are subject to further change through thinking, inhibition, extinction,
fatigue, etc. (28). Thus, attitudes are subject to alteration, main-
tenance and breakdown through manipulation of the same order of vari-
ables as those producing their original acquisition. All forms of
learning conceivably provide bases for the acquisition of attitudes.

A study of attitudes toward mathematics by Aiken (4) presented
some interesting results. This study was done with 160 college females
from a southeastern women's college. Aiken was able to conclude: (1)
individuals with apparently identical abilities and seemingly similar
experiences with mathematics may have quite different attitudes toward
the subject, and (2) feelings toward mathematics are determined by the
pattern of reward that the individual receives in mathematics. The
remaining findings suggest that attitudes toward mathematics are not
highly related to attitudes toward other academic subjects. However,
Aiken found attitudes toward mathematics to be highly related to
students' statements about previous teachers of mathematics.

A study of attitudes by Malone and Freel (50), which involved 143
lower division college students of Massachusetts State Teachers College,
supported the conclusion that students' attitudes toward mathematics
are changed in relation to the increase in the practical value of mathe-
matics. From an investigation which used freshmen from a southeastern
college as the population, Aiken and Dreger (8) concluded that atti-
tudes toward mathematics are related to achievement and are possibly
modified when related to applications.

An international study designed to assess the mathematical achieve-
ment of thirteen through seventeen year-old (terminal secondary)

students in a dozen countries is reported by Husen (37). Extensive
data concerning attitudes, interests and certain other variables were
collected. It was found that achievement was positively correlated
with interest in mathematics at all levels in all twelve countries. Of
the five attitude scales which were administered, three are of particu-
lar interest: (1) measure of attitudes toward mathematics as a process,
(2) measure of attitudes about the difficulties of learning mathematics,
and (3) measure of attitudes concerning the place of mathematics in
society. One of the findings concerning the attitude toward mathematics
as a process (a measure of the extent to which mathematics is viewed as
fixed, as opposed to developing or changing) stated that in all coun-
tries studied, the upper-level (older) students considered mathematics
as less changing than did the lower-level (younger) students. There
also was a tendency for students in countries in which the "New Mathe-
matics" was taught to see mathematics as more open and changing.

Scores on the measure of the perceived difficulties of learning
mathematics indicated that upper-level students tended to perceive
mathematics as more difficult and demanding. Interestingly enough,
scores on the measure of the place of mathematics in society indicated
that mathematics was viewed as less socially vital or valuable by
students with the longest exposure to it and by students in countries
where English is spoken. In summarizing, Husen concluded:

> We may say, in general, that in those countries where
> achievement is high, pupils have a greater tendency to per-
> ceive mathematics as a fixed and closed system, as difficult
> to learn, for an intellectual elite, and as important to the
> future of human society (37, p. 45).

The teachers who participated in the field testing of School
Mathematics Study Group (SMSG) materials reported that students now

seemed more interested in studying mathematics than formerly and that classroom sessions were very stimulating and challenging to the student and teacher alike. This, although not an experiment, lends credence to the claim that attitudes toward mathematics may be altered (75). Fortunately, Natkin's experiment, as reported by Aiken (5), substantiates this claim by showing that it is possible, by means of a well controlled experiment, to affect anxiety toward mathematics, if only for a short time.

Bassham, Murphy and Murphy (11) noted that to change a pupil's attitude toward mathematics, his perception of himself in relation to mathematical materials must be changed. Many writers, e.g., Lerch (43), Tulock (71), have observed that pupils who consistently fail mathematics lose self-confidence and develop feelings of dislike and hostility toward the subject. To cope with such negative attitudes, the teacher must provide success experiences for the learner; the child should be taught to set reasonable goals that culminate in the reward of success. It is generally accepted that if a person has a satisfying experience, he will develop a favorable attitude toward the situation in which he had that experience.

Among other findings, some of the past studies support the generalization that attitudes do change while students are enrolled in a course and can be measured by pre- and post-testing. It has been demonstrated on numerous occasions that taking interests, attitudes, or levels of anxiety into account in designing mathematics tests and lessons can improve performance. However, the concepts which underlie attitudes are evaluative in nature and specify some degree of preferability (e.g., better than, cleaner than, more vicious than, etc.).

The precise nature of the preferability depends upon the goal orientations of the conceiver.

This review is not exhaustive, nor does it purport to summarize all findings concerning attitude toward mathematics. It does, however, suggest that much is known about attitude toward mathematics and much has been done concerning studying attitude toward mathematics. The author believes, however, in heeding the cautionary note of Wilbur Dutton, who has done extensive work concerning mathematical attitude modification. Dutton writes, ". . .continued study should be made of changing negative attitudes toward arithmetic at the university level (21, p. 424)."

## Methods

While we usually think of testing procedures in terms of their validity as measures of student achievement, the function of these instruments for promoting learning may be even more important.

In some of the earliest experiments in this area, Jones, as reported by McKeachie (51), found that immediate testing after a psychology lecture resulted in improved retention. The good effects of testing persisted or increased over an eight-week period. Jones's results supporting the value of immediate feedback coincide with an experiment in a government class (25) in which students having weekly noncredit quizzes made better scores on monthly tests than a nonquizzed control group. Similarly, in a remedial English course at Purdue (49), students who wrote forty themes that were evaluated in class made greater improvement on a test of English usage than a group which had workbook drill and wrote fourteen themes, individually corrected by the

instructor. Similar results were noted in the study by Guetzkow, Kelly and McKeachie (33).

Tests provide knowledge of results, one of the major elements in learning, and we would expect that the more information contained in the feedback, the greater its value. In an experiment in the Air Force, reported by McKeachie (51), performances benefited from return of multiple-choice tests together with information about why the alternative chosen was wrong and why the correct alternative was right. This technique proved superior to four other techniques which gave less complete knowledge of results, ranging down to returning only a score on the total examination. In a related study, McKeachie and Hiler (52) found that students required to answer study questions on a topic per-formed better on test questions concerning that topic than students not given the study questions. Also, students required to answer study questions on a topic tended to do better than those whose answers were not required or graded. Thus, the principle that knowledge of results facilitates learning is perhaps one of the few generalizations clearly supported by research on college teaching.

A curriculum investigation by Maertens (48) may be cited as much as an illustration of a controlled experiment as for its specific re-sults. Also related to attitudes, the study is mentioned here because the methods used in Maertens' experiment are analogous to the methods designated for this investigation, with the effects of the methods being judged by attitude response. The experiment designed to assess the differential effects of the curriculum practice of assigning homework in arithmetic on the attitudes of third-grade pupils toward school, teacher, arithmetic, homework, spelling and reading. There were three

treatments: control (no homework), common practice (regular teacher assigns homework), and experimenter-prepared homework. Pupils were randomly assigned to three classrooms within each of four schools, and within each classroom pupils were classified into three levels according to intellectual ability. An analysis of the data revealed no statistically significant differences among the three treatments, which led Maertens to conclude that arithmetic homework does not uniformly affect pupils' attitudes toward arithmetic and the five other sources referred to above. Consequently, teachers need not omit purposeful homework as a general practice because of fear that it may create negative pupil attitudes.

An experiment by Angell (9) was designed to determine the effect of immediate and delayed knowledge of quiz results on three types of learning outcome in freshman chemistry: knowledge of facts and principles, application of facts and principles in non-quantitative problems, and application of facts and principles in quantitative problems. Students in the experimental group obtained immediate knowledge of quiz results by means of a punchboard developed by Angell and Troyer (10). Delayed knowledge of results was obtained through the use of IBM answer-sheets which were scored and returned to the students at the meeting following the taking of the quiz. Differences between scores on a final examination were statistically significant in favor of the experimental group that used the punchboard and received immediate knowledge of results.

Among other conclusions of Pressey (59, 60), who published results of an extensive program of research with tests which students scored for themselves, were: (1) test taking is transformed into

self-instruction by the immediate knowledge of mistakes, and (2)

supplemental use of the tests improves performance on regular objective

tests.

A critical commentary on some related experiments by Angell and

Troyer (10), Little (46), J. C. Peterson (57) and Pressey (59) was pre-

sented by Porter (58). Porter indicated that, in some of these

previous experiments,

> . . .immediacy of reinforcement of the punchboard groups
> was not responsible for their superiority, but lack of
> knowledge of results in the control groups was responsi-
> ble for their inferiority (58, p. 138).

Porter further pointed out:

> A crucial test of the value of immediate reinforce-
> ment has to meet the following, so far unattained,
> criteria: (1) Provide both experimental and control
> groups with knowledge about the correctness of their
> responses. (2) Reinforce subjects in the experimental
> group as quickly as possible after a response has been
> made. (3) Delay reinforcement of the control group
> (58, p. 139).

### Summary

With respect to methods, it shall be to the three points mentioned

by Porter above that this investigation addresses itself. This investi-

gation also supposes that frequent measurement will result in steadier

application of the individual to the the task at hand, this instruction-

al function of measurement being best served when divorced from the

regular process of achievement evaluation. These criteria are important

ideas that helped dictate the design of this study.

With respect to attitudes, the review of the literature, to some

extent, supports the folowing assertions (among others) that attitudes

toward mathematics are:

1. Modifiable.

2. Measurable.

3. Developed during instruction in mathematics, even within one course period of time.

4. Of practical value to educators for planning techniques of mathematical instruction.

CHAPTER III

THE EXPERIMENT

The Experimental Design and Sample

This work is a partial extension of previous study formulated in
the area of attitudes (2), which used subjects from a population simi-
lare to the population from which Math 1314 is drawn. For this reason
the population for this study was chosen from Math 1314. This course,
possibly more than any mathematics course taught at Oklahoma State
University, is the potential vehicle for altering attitudes in mathe-
matics.

For the Fall Semester, 1974, Math 1314 was taught in two large
sections, each section of which consisted of two one-hour lectures per
week and three discussion sessions. Each discussion session met for
two one-hour classes per week, and each student was assigned to attend
one of these discussion sessions. One of these large sections was
randomly chosen to participate in the experiment, and thus the error
that could be caused by the variation of instructors was eliminated.

One professor and one graduate assistant in the Department of
Mathematics were assigned to teach the section that had been chosen to
participate in the experiment. The three discussion sessions were then
randomly assigned to either Experimental Group One ($E_1$), Experimental
Group Two ($E_2$), or to the Control Group (C). The procedure used in $E_1$

was one quiz per week in the discussion session; the quiz evaluated by
the graduate assistant and used as a determining factor in the computa-
tion of the final grade for each student in this group. The procedure
used in $E_2$ was one quiz per week in the discussion session; the quiz
evaluated as soon as possible, but no grade reported to the student.
These quizzes were not used in the computation of the final grade for
the students in this group. C was taught by a traditional method in
the discussion sessions. In all respects, except the quiz procedures
mentioned above, the groups were treated alike.

Since the investigation was pertinent to attitude and achievement
modification, preassessments and postassessments of attitude and
achievement were conducted. A pretest and a posttest of achievement
were given to all groups and the results of this evaluation served in
analyzing hypotheses $H_1$. Similarly, a pretest and posttest of atti-
tudes were given. This Attitude Survey consisted of two parts, Part A
and Part B. The results from Part A were used in analyzing hypotheses
$H_2$ - $H_6$. The results from Part B were used in analyzing the remaining
hypotheses, $H_7$ - $H_{26}$. A discussion of these tests will follow in sub-
sequent sections of this chapter.

There are many natural settings in which the researcher can intro-
duce something like a true experimental design into his procedures
(e.g., the "when" and "to whom" of measurement), even though he lacks
the ability to randomize selection of students, assignment of students
and exposure to treatments. However, if the results of experiments of
these types are treated correctly, they can be useful and, indeed,
offer some advantages, one of which is the advantage of an experiment
done without the students so informed. For these reasons, Campbell

and Stanley (17, p. 34) believe the design of studies such as the one reported here are sufficiently probing to be well worth employing where more efficient probes are unavailable.

Thus, in summary, the basic design of the experiment is one comparing three experimental treatments that were randomly assigned to three intact groups of Math 1314 students enrolled for the Fall Semester, 1974, at Oklahoma State University. Pretests and posttests of achievement and attitudes were given to determine the initial status of the groups and to analyze any differences that may have arisen at the conclusion of the experiment.

## The Measuring Instruments

The purpose of measurement is to extend the power and the precision of observation. This is as true for education as it is for any discipline. The precision of measurements in education is probably less than, for example, those in the natural sciences. This lack of precision of educational measurements is perhaps due not only to the differences in the sensitivity of the instruments used but also to the differences in the stability of what is measured. Perhaps behavior is the most variable of all phenomena which man attempts to observe; however, these facts only place limits on precision, not on the search for improvement. In this experiment two evaluation instruments were administered, an Attitude Survey and an Achievement measure, each of which is discussed below.

Although it has been said that there are actually no valid measures of attitudes toward mathematics (53, p. 133), the fact remains that a number of techniques--some of them quite ingenious--are

available. Although the majority of investigations concerning attitudes toward mathematics deal only with attitudes toward mathematics in general, attitudes toward specific courses or types of content materials can also be assessed.

The Attitude Survey used in this experiment consisted of forty-seven statements and is divided into two parts, Part A and Part B. Each of the parts represents a separate instrument. The first instrument (Part A), developed by Lewis R. Aiken, and hereafter called the Aiken Attitude Scale, encompassed the first twenty statements and was used to determine the students' attitudes toward mathematics (general). It was chosen because it is one of few recognized as acceptable, has good validity and reliability (test-retest $r = .94$) and has been used with success numerous times (64, p. 242). This scale was constructed by Likert's methods of summated ratings, and versions of this scale have been used with sixth graders, junior and senior high school students and college undergraduate and graduate students. Consistent with the findings of other investigations, the results show that the reliability and validity of this scale vary somewhat with grade level, being generally more reliable and valid in high school and college. Possible reasons for this could be that not only do attitudes become more stable with maturity, but the degree of self-insight and conscientiousness with which students can express their attitudes increases with age. In addition, problems of readability and interpretability of self-report inventories are more serious in the lower grades (7, p. 230).

On the Aiken Attitude Scale, of the twenty items, ten were positive items and ten were negative items. Responses were scored on a

5-4-3-2-1 basis for the positive items for agreement with Strongly

Agree, Somewhat Agree, Neither Agree Nor Disagree, Somewhat Disagree

and Strongly Disagree, respectively, and were scored on a 1-2-3-4-5

basis for Strongly Agree, Somewhat Agree, Neither Agree Nor Disagree,

Somewhat Disagree and Strongly Disagree, respectively, for the negative

items. The sum of the response score for each question was used to

give each person a score, between twenty and one hundred, on this

measure. This score was defined to be the student's Attitude Toward

Mathematics (general) at the time the student took the evaluation. Al-

though the Aiken Attitude Scale yields ordinal data, for this experi-

ment the data were treated as interval data.

The second instrument (Part B), developed by Douglas B. Aichele,

and hereafter called the Aichele Attitude Scale, contained the remain-

ing twenty-seven statements. These statements were divided into the

following categories: (1) Part I, Views Concerning the Learning of

Mathematics, (2) Part II, Views Concerning Mathematics as a Process,

(3) Part III, Views Concerning the Place of Mathematics in Society,

and (4) Part IV, Views Concerning School and Learning Generally. The

Aichele Attitude Scale was used to determine the students' attitudes

toward each of the four areas mentioned above.

The Aichele Attitude Scale is a Thurstone scale and was construct-

ed in a similar fashion to the scale used in the International Study

(37). The reader is asked to see Aichele (2, p. 37-42) for the de-

scription of the construction of this scale and the assumptions in-

volved in its construction. Scale values were obtained for each state-

ment in the Aichele Attitude Scale, and based on these values, an

attitude score for each of the four categories was calculated for each

student involved in Math 1314 by finding the median of the scale values

with which the student agreed. This value served as an index of the

intensity of each student's feeling toward each of the previously de-

scribed categories in the Aichele Attitude Scale. These statements and

their scale values are given in Appendix B, where high positive scale

values are associated with favorable statements. Also given in

Appendix B are the coefficients of correlation for the reliability of

each part of the Aichele Attitude Scale.

Permission to use the Aiken Attitude Scale and the Aichele Atti-

tude Scale was graciously granted by Lewis R. Aiken and Douglas B.

Aichele, respectively, and the final form of the Attitude Survey appears

in Appendix A.

The instrument used to evaluate achievement was the Structure of

the Number System, Form A and Form B, that was prepared by the Educa-

tional Testing Service, Cooperative Mathematics Test Department. These

are achievement tests that measure understanding of the real number

system up to the rational numbers. The tests consisted of forty multi-

ple-choice questions that, among other things, sampled the following

topics: arithmetic judgment, operational properties (closure, commu-

tative, associative and distributive), inverses and identities, proper-

ties of the integers, place value, factors, division by zero, divisors

and multiples, prime numbers, number lines, number systems other than

ten, modular arithmetic and Roman Numerals.

These two tests were selected because they were the only com-

mercially produced tests readily available that directly related to the

objectives of the experiment. They stress understanding of facts,

principles, and relationships, and do not emphasize computational

skills. Furthermore, the tests are measures of developed abilities, and thus, their content validity is very important. The reliabilities reported by Educational Testing Service on measures of internal consistency were .86 for Form A and .84 for Form B. These were computed using the Kuder-Richardson formula 20. Form A had an item-total score discrimination correlation of .50 and that of Form B was .48, thus indicating that the tests are effective in discriminating between high and low ability students. The equivalence of these two alternate forms was also very good (30, p. 28-29).

The use that was made of the various measuring instruments is included in the next section.

## The Collection of the Data

The evaluation instruments mentioned earlier, the Attitude Survey, consisting of the Aiken and Aichele Attitude Scales, and the Structure of the Number System, Form A and Form B, were administered in a pretest, posttest fashion with the pretest of the Attitude Survey given August 27, 1974, the pretest of the Structure of the Number System, Form A, given August 29, 1974, the posttest of the Attitude Survey given December 5, 1974, and the posttest of the Structure of the Number System, Form B, given December 10, 1974.

Of the students involved in Math 1314, data from those who did not take both the pretest and posttest of the Attitude Survey or those who withdrew from the University or the course were discarded in the analysis of the attitude data. Similar action was taken with regard to the data on the pretest and posttest of achievement, and hence, it was possible for someone to be part of the analysis for the sample on

attitude, but not part of the analysis for the sample on achievement, and vice versa. In the light of the above, it is not surprising that N = 89 for the analysis of the attitude data while N = 87 for the analysis with respect to achievement.

## Treatment of the Data

In a very fundamental sense, experimental results never "confirm" or "prove" a theory--rather, the successful theory is tested and escapes being disconfirmed. The word "prove," by being frequently employed to designate deductive validity, has acquired in our generation a connotation inappropriate both to its older uses and to its application to inductive procedures such as experimentation. The results of an experiment "probe" but do not "prove" a theory. An adequate hypothesis is one that has repeatedly survived such probing-- but it may always be displaced by a new probe.

In many experimental situations, we wish to compare groups that are initially unlike, either in the variable under study, or some presumably related variable. Despite such constraints as difficulties in sampling and design, inadequate control of some conditions, etc., the process, nevertheless, has payoff and it is considered eminently worth the effort, even essential for decision-making. Such research is not esoteric. Although it uses statistics, measurement, and other research tools, institutional research is essentially a highly organized form of question answering. It is also pragmatic. It is concerned with what "works" and how to make what works work better for the common good of the institution.

Upon the collection of the data the hypotheses were tested by

various statistical methods. Hypothesis $H_1$, $H_2$ and $H_{23}$ - $H_{26}$ were
tested by analysis of covariance, where the scores obtained on the pre-
test of the Aiken Attitude Scale served as the covariate in analyzing
hypothesis $H_2$, the scores obtained on the Structure of the Number
System, Form A, given as a pretest, served as the covariate in analyz-
ing hypothesis $H_1$ and the scores obtained on each part of the Aichele
Attitude Scale served as the covariates in analyzing hypotheses $H_{23}$ -
$H_{26}$, respectively.

The design of the experiment necessitated the use of analysis of
covariance as was verified with Dr. Bill F. Elsom, Director of the
Bureau of Tests and Measurements at Oklahoma State University. Garrett
explains the uses of analysis of covariance when he states:

> Analysis of covariance represents an extention
> of the analysis of variance to allow for the correlation
> between initial and final scores. Covariance analysis
> is especially useful for experiments in the behavioral
> sciences where for various reasons it is impossible or
> quite difficult to equate control and experimental groups
> at the start: a situation which often obtains in actual
> experiments. Through covariance analysis one is able
> to affect adjustments in final or terminal scores which
> will allow for differences in some initial variable
> (29, p. 295).

Speaking about the design of this experiment, Campbell and Stanley
point out the following:

> The more similar the experimental and control
> groups are in their recruitment, and the more this simi-
> larity is confirmed by the scores on the pretest, the
> more effective this control becomes. Assuming that
> these desiderata are approximated for purposes of
> internal validity, we can regard the design as control-
> ing the main effects of history, maturation, testing
> and instrumentation, in that the difference for the
> experimental group between pretest and posttest (if
> greater than that for the control group) cannot be
> explained by main effects of these variables such as
> would be found affecting both the experimental and the
> control group (17, p. 47-48).

Hypotheses $H_3$ - $H_6$ were tested using the Wilcoxen test. The Wilcoxen test was used because this test provides not only direction of change, but also the magnitude of change for each participant.

Hypotheses $H_7$ - $H_{22}$ were tested using the Sign test. As mentioned earlier, on the presentation of the Attitude Survey each student enrolled in Math 1314 was assigned a value for each of the four parts of the Aichele Attitude Scale. Thus, a value was received for the initial as well as the terminal presentation of the Attitude Survey. The two values received on Part I, Views Concerning the Learning of Mathematics, of the Aichele Attitude Scale were compared by the Sign test to test hypotheses $H_7$ - $H_{10}$. The two values received on Part II, Views Concerning Mathematics as a Process, of the Aichele Attitude Scale were compared by the Sign test to test hypotheses $H_{11}$ - $H_{14}$. The two values received on Part III, View Concerning the Place of Mathematics in Society, of the Aichele Attitude Scale were compared by the Sign test to test hypotheses $H_{15}$ - $H_{18}$. The two values received on Part IV, Views Concerning School and Learning Generally, of the Aichele Attitude Scale were compared by the Sign test to test hypotheses $H_{19}$ - $H_{22}$.

The Sign test is appropriate to the situation where the researcher wishes to ascertain whether or not two conditions are different. The only assumption underlying this test is that the variable under consideration has a continuous distribution (66, p. 68). No assumptions are made concerning the form of the distributions of differences, or that all subjects are selected from the same distribution.

The following formula for the Sign test has been corrected for continuity and was used to test hypotheses $H_7$, $H_9$ - $H_{11}$, $H_{13}$ - $H_{15}$,

$H_{17}$ - $H_{19}$ and $H_{21}$ - $H_{22}$.

$$z = \frac{(x \pm .5) - N/2}{(1/2)\sqrt{N}}$$

where N is the number of untied pairs and x + .5 is used when x is less than N/2, and x - .5 is used when x is greater than N/2. In the event N is less than twenty-five, the above is not used, but one can easily check the significance by appealing to tables (66, p. 250), and this method was used to test hypotheses $H_8$, $H_{12}$, $H_{16}$ and $H_{20}$ (66, p. 71-72).

Although not specifically stated as hypotheses, the author deemed it appropriate to check for significance of changes between initial presentation and terminal presentation of each item in the Aichele Attitude Scale. The McNemar Test for Significance of Changes was used for analysis and the form of a fourfold table to categorize the responses to each item is presented in Table I.

TABLE I

FORM OF FOURFOLD TABLE OF FREQUENCIES USED IN
TESTING SIGNIFICANCE OF CHANGES IN
PERFORMANCE ON THE AICHELE
ATTITUDE SCALE

|  |  | Terminal Presentation | |
|---|---|---|---|
|  |  | Agree | Disagree |
| Initial Presentation | Agree | B | A |
|  | Disagree | D | C |

The McNemar test is concerned with cells A and D in Table I, since these cells represent the total number of students who changed responses to an item on the initial presentation and the terminal presentation of the Aichele Attitude Scale. The McNemar test is given according to the formula:

$$\chi^2 = \frac{(A - D)^2}{A + D}$$

where A and D are given according to Table I and df = 1 (66, p. 64).

The approximation by the chi-square distribution to the sampling distribution becomes an excellent one if correction for continuity is performed. This correction is necessary because a continuous distribution (chi-square) is used to approximate a discrete distribution. Thus, the McNemar test with Yates Correction for Continuity was used according to the formula:

$$\chi^2 = \frac{(\mid A - D \mid - 1)^2}{A + D}$$

where A and D are given according to Table I and df = 1 (66, p. 64).

If the expected frequency, (1/2)(A + D), is less than five, then the binomial test was used rather than the corrected McNemar test. For the binomial test, N = A + D, and x is the smaller of the observed frequencies, either A or D, and the significance can then be checked by using appropriate tables (66, p. 250).

## Summary

The need for such a display of distinct statistic techniques was dictated by the five areas in the statement of the problem and the

and the resulting hypotheses formulated according to these areas.

Treating the Aiken Attitude Scale as yielding interval data implies that analysis of covariance is appropriate for testing hypotheses $H_1$, $H_2$, and $H_{23}$ - $H_{26}$. While either the Wilcoxen test or the Sign test could have been used for hypotheses $H_3$ - $H_{22}$, the Wilcoxen test was chosen for hypothesis $H_3$ - $H_6$ and the Sign test was chosen for hypotheses $H_7$ - $H_{22}$. This division was necessitated by the differing scales used in scoring the Aiken Attitude Scale and the Aichele Attitude Scale, with the Aiken Attitude Scale yielding scores more appropriate to the ranking method.

The McNemar test was used because it measures significance of change, a measurement appropriate when the Aichele Attitude Scale is administered in a pretest-posttest fashion.

CHAPTER IV

RESULTS

Chapter IV presents the results of the analysis of the data, and
is organized according to the statistical techniques used in the ana-
lysis. The .10 level of significance was designated for the rejection
of the null hypotheses.

## Results of the Analysis of Covariance

Analysis of covariance was used to test hypotheses $H_1$, $H_2$ and
$H_{23}$ - $H_{26}$. The results of these tests are presented according to the
research questions presented in Chapter I.

A. Hypothesis $H_1$ was rejected at the .10 level of significance.
That is, there is a significant statistical difference between the
methods used in the discussion sections and resulting achievement of
students enrolled in Math 1314. The critical F value was 2.37 and the
calculated F value was 2.78. Following this rejection, the Student t-
test, based upon the standard error of the difference between two ad-
justed posttest means, was used to determine the location of the
significance (67, p. 316).

In comparing $E_1$ and $E_2$, t = .631, which is not significant at the
.10 level. Hence, groups $E_1$ and $E_2$ do not differ with respect to their
adjusted posttest means.

In comparing $E_2$ and C, t = 2.200, which is significant at the .10

level. Hence, groups $E_2$ and C differed significantly with respect to their adjusted posttest means.

In comparing $E_1$ and C, t = 1.688, which is significant at the .10 level. Hence, groups $E_1$ and C differed significantly with respect to their adjusted posttest means.

Table II lists by section the means of the pretest, posttest, and the adjusted means of the posttest of the scores on the Achievement Test.

TABLE II

MEANS AND ADJUSTED MEANS ON THE
ACHIEVEMENT TEST

|  | Form A | Form B | Adjusted |
|---|---|---|---|
| $E_1$ | 18.767 | 25.733 | 25.763 |
| $E_2$ | 18.320 | 26.080 | 26.456 |
| C | 19.219 | 24.344 | 24.023 |

B. Hypothesis $H_2$ could not be rejected at the .10 level of significance. That is, there is no significant difference between method used in the discussion sections and resulting attitudes toward mathematics (general) of the students enrolled in Math 1314. The critical F value was 2.37 and the calculated F value was .053.

E. Hypothesis $H_{23}$ could not be rejected at the .10 level of significance. That is, there is no significant difference between

method used in the discussion sections and resulting attitudes of students toward the learning of mathematics. The critical F value was 2.37 and the calculated F value was .286.

Hypothesis $H_{24}$ could not be rejected at the .10 level of significance. That is, there is no significant difference between method used in the discussion sections and resulting attitudes of students toward mathematics as a process. The critical F value was 2.37 and the calculated F value was .740.

Hypothesis $H_{25}$ could not be rejected at the .10 level of significance. That is, there is no significant difference between method used in the discussion sections and resulting attitudes of students toward the place of mathematics in society. The critical F value was 2.37 and the calculated F value was 1.611.

Hypothesis $H_{26}$ could not be rejected at the .10 level of significance. That is, there is no significant difference between method used in the discussion sections and resulting attitudes of students toward school and learning generally. The critical F value was 2.37 and the calculated F value was 1.035.

A summary of the results of the analysis of covariance can be found in Chapter V.

## Results of the Wilcoxen Test

The Wilcoxen test was used to test hypotheses $H_3$ - $H_6$. The results of these tests are presented according to the research questions presented in Chapter I, and the results are summarized in Table III.

C. Hypotheses $H_3$ and $H_4$ could not be rejected at the .10 level of significance. That is, there is no significant difference between

TABLE III

WILCOXEN TEST RESULTS

| group | number of students | number and kind of attitude changes | | | sum of ranks with less frequent sign | z-scores | p |
|---|---|---|---|---|---|---|---|
| | | positive | negative | unchanged | | | |
| E$_1$ | 31 | 17 | 12 | 2 | 153.5 | 1.38 | .168 |
| E$_2$ | 25 | 13 | 11 | 1 | 123 | .77 | .441 |
| C | 33 | 19 | 11 | 3 | 136.5 | 1.97 | .049[*] |
| Math 1314 | 89 | 49 | 34 | 6 | 1228 | 2.34 | .019[*] |

[*]Significant at the .05 level

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initial attitudes of students in Group $E_1$ toward mathematics (general), and terminal attitudes of students in Group $E_1$ toward mathematics (general), and there is no significant difference between initial attitudes of students in Group $E_2$ toward mathematics (general) and terminal attitudes of students in Group $E_2$ toward mathematics (general).

Hypotheses $H_5$ and $H_6$ were rejected at the .10 level of significance. That is, there is a significant difference between initial attitudes of students in Group C toward mathematics (general) and terminal attitudes of students in Group C toward mathematics (general), and there is a significant difference between initial attitudes of students enrolled in Math 1314 toward mathematics (general) and terminal attitudes of students enrolled in Math 1314 toward mathematics (general).

Thus, these results indicate that the attitudes of the students in $E_1$ and $E_2$ did not change significantly while the attitudes of the students in C and in the class as a whole did change significantly, with all classes and the class as a whole exhibiting more positive responses on the terminal measure of attitudes than on the initial measure of attitudes toward mathematics (general) as measured by the Aiken Attitude Scale.

More information concerning the results of the Aiken Attitude Scale is included in Table IV, although it is not used for purposes of statistical analysis. Table IV provides the means and standard deviations of $E_1$, $E_2$, C and Math 1314 on both the initial and terminal presentation of the Aiken Attitude Scale, where scores range from 20 to 100.

TABLE IV

AIKEN ATTITUDE SCALE RESULTS

| Group | Pretest | Posttest |
|-------|---------|----------|
| $E_1$ | *m=49.2<br>**sd=20.7 | m=52.9<br>sd=18.9 |
| $E_2$ | m=58.6<br>sd=20.8 | m=60.8<br>sd=21.9 |
| C | m=52.6<br>sd=14.9 | m=56.5<br>sd=19.2 |

*mean of the group

**standard deviation of the group

A summary of the results of the Wilcoxen test can be found in Chapter V.

## Results of the Sign Test

The Sign test was used to evaluate hypotheses $H_7$ - $H_{22}$. The results of these tests are presented according to the research questions presented in Chapter I, and the results are summarized in Table V.

D. Hypotheses $H_7$, $H_8$, $H_{10}$ - $H_{15}$ and $H_{17}$ and $H_{18}$ could not be rejected at the .10 level of significance. That is, (1) there is no significant difference between initial attitudes of students in Group $E_1$ concerning the learning of mathematics and terminal attitudes of students

TABLE V

SIGN TEST RESULTS

| Group | Hyp[a] | Scale[b] | N[c] | x[c] | D[d] | z-score | p[f] |
|---|---|---|---|---|---|---|---|
| $E_1$ | $H_7$ | I | 21 | 7 | - | ---- | .190 |
| | $H_{11}$ | II | 24 | 11 | - | ---- | .838 |
| | $H_{15}$ | III | 26 | 12 | - | ---- | .562 |
| | $H_{19}$ | IV | 27 | 4 | + | 3.464 | .001*** |
| $E_2$ | $H_8$ | I | 19 | 7 | + | ---- | .360 |
| | $H_{12}$ | II | 21 | 10 | + | ---- | .999 |
| | $H_{16}$ | III | 21 | 6 | + | ---- | .078** |
| | $H_{20}$ | IV | 20 | 5 | + | ---- | .042*** |
| C | $H_9$ | I | 21 | 6 | - | ---- | .078* |
| | $H_{13}$ | II | 29 | 11 | - | 1.114 | .267 |
| | $H_{17}$ | III | 31 | 12 | - | 1.078 | .280 |
| | $H_{21}$ | IV | 26 | 6 | + | 2.550 | .011** |
| Math 1314 | $H_{10}$ | I | 61 | 25 | - | 1.280 | .201 |
| | $H_{14}$ | II | 74 | 33 | - | .814 | .428 |
| | $H_{18}$ | III | 78 | 38 | - | .113 | .910 |
| | $H_{22}$ | IV | 73 | 15 | + | 4.196 | .000*** |

[a]Hypothesis being tested.

[b]I, II, III and IV refer to Part I, Part II, Part II and Part IV, respectively, of the Aichele Attitude Scale.

[c]N refers to the number of students who did not have the same score on the initial and terminal presentation of the scale, and x refers to the number of students with the less frequent sign.

[d]"+" indicates more students had higher terminal scores, "-" indicates more students had higher initial scores.

[e]z-scores are only reported where applicable, otherwise probabilities were computed from Siegel (66, p. 250).

[f]"*", "**", "***" indicate significance at the .10, .05, and .01 levels, respectively.

in Group $E_1$ concerning the learning of mathematics, (2) there is no significant difference between initial attitudes of students in Group $E_2$ concerning the learning of mathematics and terminal attitudes of students in Group $E_2$ concerning the learning of mathematics, (3) there is no significant difference between initial attitudes of students enrolled in Math 1314 concerning the learning of mathematics and terminal attitudes of students enrolled in Math 1314 concerning the learning of mathematics, (4) there is no significant difference between initial attitudes of students in Group $E_1$ concerning mathematics as a process and terminal attitudes of students in Group $E_1$ concerning mathematics as a process, (5) there is no significant difference between initial attitudes of students in Group $E_2$ concerning mathematics as a process and terminal attitudes of students in Group $E_2$ concerning mathematics as a process, (6) there is no significant difference between initial attitudes of students in Group C concerning mathematics as a process and terminal attitudes of students in Group C concerning mathematics as a process, (7) there is no significant difference between initial attitudes of students enrolled in Math 1314 concerning mathematics as a process and terminal attitudes of students enrolled in Marth 1314 concerning mathematics as a process, (8) there is no significant difference between initial attitudes of students in Group $E_1$ concerning the place of mathematics in society and terminal attitudes of students in Group $E_1$ concerning the place of mathematics in society, (9) there is no significant difference between initial attitudes of students in Group C concerning the place of mathematics in society and terminal attitudes of students in Group C concerning the place of mathematics in society, and (10) there is no significant difference

between initial attitudes of students enrolled in Math 1314 concerning the place of mathematics in society and terminal attitudes of students enrolled in Math 1314 concerning the place of mathematics in society.

Hypotheses $H_9$, $H_{16}$ and $H_{19}$ - $H_{22}$ were rejected at the .10 level of significance. That is, (1) there is a significant difference between initial attitudes of students in Group C concerning the learning of mathematics and germinal attitudes of students in Group C concerning the learning of mathematics, with more negative attitudes toward the learning of mathematics exhibited on the terminal presentation, (2) there is a significant difference between initial attitudes of students in Group $E_2$ concerning the place of mathematics in society and terminal attitudes of students in Group $E_2$ concerning the place of mathematics in society, with more positive attitudes toward the place of mathematics in society exhibited on the terminal presentation, (3) there is a significant difference between initial attitudes of students in Group $E_1$ concerning school and learning generally and terminal attitudes of students in Group $E_1$ concerning school and learning generally, with more positive attitudes toward school and learning generally exhibited on the terminal presentation, (4) there is a significant difference between initial attitudes of students in Group $E_2$ concerning school and learning generally and terminal attitudes of students in Group $E_2$ concerning school and learning generally, with more positive attitudes toward school and learning generally exhibited on the terminal presentation, (5) there is a significant difference between initial attitudes of students in Group C concerning school and learning generally and terminal attitudes of students in Group C concerning school

and learning generally, with more positive attitudes toward school and learning generally exhibited on the terminal presentation, and (6) there is a significant difference between initial attitudes of students enrolled in Math 1314 concerning school and learning generally and terminal attitudes of students enrolled in Math 1314 concerning school and learning generally, with more positive attitudes toward school and learning generally exhibited on the terminal presentation.

It is worth noting that even though hypotheses $H_7$, $H_{10}$, $H_{11}$, $H_{13}$, $H_{14}$, $H_{15}$, $H_{17}$ and $H_{18}$ could not be rejected, the measurement indicates that with respect to these hypotheses attitudes can be considered as moving in the negative direction between the initial and terminal administrations of the Aichele Attitude Scale. The measurement with regard to the other non-rejected hypotheses, $H_8$ and $H_{12}$, indicated that with respect to these hypotheses attitudes can be thought of as moving in a positive direction between the initial and terminal administrations of the Aichele Attitude Scale.

In viewing Table V, it is noticed that only $E_2$ showed a positive direction with respect to all parts of the Aichele Attitude Scale, while $E_1$, C and Math 1314 all showed negative direction with respect to Part I (Views concerning the learning of mathematics), Part II (Views concerning mathematics as a process) and Part III (Views concerning the place of mathematics in society) and only showed a positive direction with respect to Part IV (Views concerning school and learning generally).

A summary of the results of the Sign test can be found in Chapter V.

Results of the McNemar Test

The McNemar test was used to test for significance of change with regard to each item on the Aichele Attitude Scale, and the results are summarized with respect to each of the four groups, $E_1$, $E_2$, C and Math 1314, in Tables VI, VII, VIII and IX, respectively.

## Aichele Attitude Scale for $E_1$

Categorical percentages can be found in Table VI. Table VI indicates that there were no significant changes in responses to any of the items on the Aichele Attitude Scale, however, discussion of some observations made from Table VI are presented below.

Table VI reports that 90 per cent of the students disagreed with statement 9--Very few people can learn mathematics--on both presentations, 97 per cent disagreed with statement 27--Only people with a special talent can learn mathematics--on both presentations and 65 per cent disagreed with statement 1--Most work in mathematics is the memorizing of information--on both presentations, while 74 per cent of the students in $E_1$ agreed with statement 24--Almost all students can learn mathematics if properly taught--on both presentations.

Although not significant, it is noted that there was an increase from 35 per cent on the initial presentation to 52 per cent on the terminal presentation who agreed with statement 5--Anyone can learn mathematics--and an increase from 65 per cent who agreed initially to 74 per cent who agreed terminally to statement 16--Any person of average intelligence can learn to understand a good deal of mathematics--.

Concerning Part II, Table VI indicates that 68 per cent disagreed with item 25--Mathematics will change rapidly in the future--on both

TABLE VI

CATEGORICAL PERCENTAGE REPRESENTATION OF RESPONSES
TO STATEMENTS ON INITIAL AND TERMINAL PRESENTATION
OF THE AICHELE ATTITUDE SCALE TO EXPERIMENTAL
GROUP 1 (N = 31)

| | Item | $A^a$ | $B^b$ | $C^c$ | $D^d$ | A+B | B+D | $\chi^{2e}$ |
|---|---|---|---|---|---|---|---|---|
| | 9 | 6 | 0 | 90 | 3 | 6 | 3 | --- |
| | 27 | 0 | 3 | 97 | 0 | 3 | 3 | --- |
| | 1 | 10 | 13 | 65 | 13 | 23 | 26 | --- |
| Part I | 5 | 6 | 29 | 42 | 23 | 35 | 52 | --- |
| | 20 | 13 | 48 | 23 | 16 | 61 | 65 | --- |
| | 16 | 10 | 55 | 16 | 19 | 65 | 74 | --- |
| | 21 | 19 | 13 | 55 | 13 | 32 | 26 | .10 |
| | 13 | 13 | 16 | 61 | 10 | 29 | 26 | --- |
| | 17 | 19 | 6 | 48 | 26 | 26 | 32 | .07 |
| Part II | 25 | 16 | 13 | 68 | 3 | 29 | 16 | --- |
| | 6 | 19 | 19 | 42 | 19 | 39 | 39 | .08 |
| | 2 | 13 | 61 | 16 | 10 | 74 | 71 | --- |
| | 10 | 13 | 61 | 16 | 10 | 74 | 71 | --- |
| | 11 | 10 | 10 | 71 | 10 | 19 | 19 | --- |
| | 3 | 6 | 10 | 74 | 10 | 16 | 19 | --- |
| | 22 | 16 | 29 | 42 | 13 | 45 | 42 | --- |
| Part III | 14 | 10 | 26 | 42 | 23 | 35 | 48 | .90 |
| | 26 | 16 | 16 | 58 | 10 | 35 | 29 | --- |
| | 18 | 19 | 23 | 52 | 6 | 42 | 29 | --- |
| | 7 | 16 | 45 | 19 | 19 | 61 | 65 | --- |
| | 8 | 0 | 0 | 100 | 0 | 0 | 0 | --- |
| | 23 | 6 | 26 | 45 | 23 | 32 | 48 | --- |
| Part IV | 4 | 3 | 90 | 0 | 6 | 94 | 97 | --- |
| | 19 | 10 | 71 | 6 | 13 | 81 | 84 | --- |
| | 12 | 16 | 0 | 68 | 16 | 16 | 16 | .10 |
| | 15 | 3 | 65 | 13 | 19 | 81 | 84 | --- |

[a]Percentage of Experimental Group 1 students agreeing with item only on initial presentation

[b]Percentage of Experimental Group 1 students agreeing with item both on initial presentation and terminal presentation

[c]Percentage of Experimental Group 1 students not agreeing with item on both initial presentation and terminal presentation

[d]Percentage of Experimental Group 1 students agreeing with item only on terminal presentation

[e]McNemar test used, if appropriate. --- indicates Binomial test used when McNemar test not appropriate

[#]Significance at the .10 level

TABLE VII

CATEGORICAL PERCENTAGE REPRESENTATION OF RESPONSES
TO STATEMENTS ON INITIAL AND TERMINAL PRESENTATION
OF THE AICHELE ATTITUDE SCALE TO EXPERIMENTAL
GROUP 2 (N = 25)

|  | Item | $A^a$ | $B^b$ | $C^c$ | $D^d$ | A+D | B+D | $\chi^{2e}$ |
|---|---|---|---|---|---|---|---|---|
| | 9 | 4 | 0 | 96 | 0 | 4 | 0 | --- |
| | 27 | 0 | 4 | 84 | 12 | 4 | 16 | --- |
| | 1 | 16 | 20 | 44 | 20 | 36 | 40 | --- |
| Part I | 5 | 8 | 32 | 44 | 16 | 40 | 48 | --- |
| | 20 | 20 | 40 | 24 | 16 | 60 | 56 | --- |
| | 16 | 8 | 64 | 8 | 20 | 72 | 84 | --- |
| | 24 | 0 | 56 | 24 | 20 | 56 | 76 | ---# |
| | 21 | 16 | 8 | 72 | 4 | 24 | 12 | --- |
| | 13 | 4 | 12 | 64 | 20 | 16 | 32 | --- |
| | 17 | 12 | 32 | 40 | 16 | 44 | 48 | --- |
| Part II | 25 | 12 | 24 | 56 | 8 | 36 | 32 | .75 |
| | 6 | 16 | 28 | 24 | 32 | 44 | 60 | --- |
| | 2 | 4 | 80 | 4 | 12 | 84 | 92 | --- |
| | 10 | 0 | 84 | 8 | 8 | 84 | 92 | --- |
| | 11 | 16 | 0 | 72 | 12 | 16 | 12 | --- |
| | 3 | 12 | 12 | 68 | 8 | 24 | 20 | --- |
| | 22 | 20 | 24 | 40 | 16 | 44 | 40 | --- |
| Part III | 14 | 20 | 32 | 28 | 20 | 52 | 52 | .10 |
| | 26 | 12 | 24 | 52 | 12 | 36 | 36 | --- |
| | 18 | 8 | 24 | 40 | 28 | 32 | 52 | --- |
| | 7 | 4 | 72 | 24 | 0 | 76 | 72 | --- |
| | 8 | 0 | 4 | 96 | 0 | 4 | 4 | --- |
| | 23 | 8 | 32 | 48 | 12 | 40 | 44 | --- |
| | 4 | 8 | 72 | 4 | 16 | 80 | 88 | --- |
| Part IV | 19 | 8 | 64 | 8 | 20 | 72 | 84 | --- |
| | 12 | 12 | 12 | 56 | 20 | 24 | 32 | --- |
| | 15 | 8 | 64 | 20 | 8 | 72 | 72 | --- |

[a]Percentage of Experimental Group 2 students agreeing with item only on initial presentation

[b]Percentage of Experimental Group 2 students agreeing with item both on initial presentation and terminal presentation

[c]Percentage of Experimental Group 2 students not agreeing with item on both initial presentation and terminal presentation

[d]Percentage of Experimental Group 2 students agreeing with item only on terminal presentation

[e]McNemar test used, if appropriate.  --- indicates Binomial test used when McNemar test was not appropriate

[#]Significance at the .10 level

TABLE VIII

CATEGORICAL PERCENTAGE REPRESENTATION OF RESPONSES
TO STATEMENTS ON INITIAL AND TERMINAL PRESENTATION
OF THE AICHELE ATTITUDE SCALE TO THE CONTROL
GROUP (N = 33)

|  | Item | $A^a$ | $B^b$ | $C^c$ | $D^d$ | A+B | B+D | $\chi^{2e}$ |
|---|---|---|---|---|---|---|---|---|
| | 9 | 0 | 0 | 100 | 0 | 0 | 0 | --- |
| | 27 | 6 | 3 | 88 | 3 | 9 | 9 | --- |
| | 1 | 12 | 27 | 42 | 18 | 39 | 45 | .10 |
| Part I | 5 | 6 | 33 | 45 | 15 | 39 | 48 | --- |
| | 20 | 12 | 61 | 21 | 6 | 73 | 67 | --- |
| | 16 | 18 | 70 | 6 | 6 | 88 | 76 | --- |
| | 24 | 21 | 61 | 9 | 9 | 82 | 70 | .90 |
| | 21 | 12 | 3 | 76 | 9 | 15 | 12 | --- |
| | 13 | 9 | 9 | 70 | 12 | 18 | 21 | --- |
| | 17 | 6 | 33 | 36 | 24 | 39 | 58 | --- |
| Part II | 25 | 9 | 15 | 61 | 15 | 24 | 30 | --- |
| | 6 | 18 | 18 | 42 | 21 | 36 | 39 | .00 |
| | 2 | 15 | 70 | 6 | 9 | 85 | 79 | --- |
| | 10 | 15 | 70 | 9 | 6 | 85 | 76 | --- |
| | 11 | 18 | 3 | 61 | 18 | 21 | 21 | .08 |
| | 3 | 24 | 3 | 64 | 9 | 27 | 12 | 1.46 |
| | 22 | 15 | 15 | 55 | 15 | 30 | 30 | .10 |
| Part III | 14 | 12 | 27 | 39 | 21 | 39 | 48 | .36 |
| | 26 | 15 | 12 | 55 | 18 | 27 | 30 | .00 |
| | 18 | 15 | 36 | 45 | 3 | 52 | 39 | --- |
| | 7 | 18 | 58 | 15 | 9 | 76 | 66 | --- |
| | 8 | 0 | 0 | 100 | 0 | 0 | 0 | --- |
| | 23 | 9 | 33 | 48 | 9 | 42 | 42 | --- |
| | 4 | 9 | 76 | 12 | 3 | 85 | 79 | --- |
| Part IV | 19 | 12 | 70 | 18 | 0 | 82 | 70 | --- |
| | 12 | 12 | 18 | 61 | 9 | 30 | 27 | --- |
| | 15 | 12 | 52 | 15 | 21 | 64 | 73 | .36 |

[a]Percentage of Control Group students agreeing with item only on initial presentation

[b]Percentage of Control Group students agreeing with item both on initial presentation and terminal presentation

[c]Percentage of Control Group students not agreeing with item on both initial presentation and terminal presentation

[d]Percentage of Control Group students agreeing with item only on terminal presentation

[e]McNemar test used, if appropriate. --- indicates Binomial test used when McNemar test not appropriate

[#]Significance at the .10 level

TABLE IX

CATEGORICAL PERCENTAGE REPRESENTATION OF RESPONSES
TO STATEMENTS ON INITIAL AND TERMINAL PRESENTATION
OF THE AICHELE ATTITUDE SCALE TO
MATH 1314 (N = 89)

|  | Item | $A^a$ | $B^b$ | $C^c$ | $D^d$ | A+B | B+D | $\chi^{2e}$ |
|---|---|---|---|---|---|---|---|---|
|  | 9 | 3 | 0 | 96 | 1 | 3 | 1 | --- |
|  | 27 | 2 | 3 | 90 | 4 | 6 | 8 | --- |
|  | 1 | 12 | 20 | 51 | 17 | 33 | 37 | .28 |
| Part I | 5 | 7 | 31 | 44 | 18 | 38 | 49 | 3.68# |
|  | 20 | 15 | 51 | 22 | 12 | 54 | 52 | .04 |
|  | 16 | 12 | 63 | 10 | 15 | 75 | 78 | .04 |
|  | 24 | 11 | 64 | 13 | 11 | 75 | 75 | .05 |
|  | 21 | 16 | 8 | 67 | 9 | 24 | 17 | 1.26 |
|  | 13 | 9 | 12 | 65 | 13 | 21 | 26 | .45 |
|  | 17 | 12 | 24 | 42 | 22 | 36 | 46 | 2.07 |
| Part II | 25 | 12 | 17 | 62 | 9 | 29 | 26 | .21 |
|  | 6 | 18 | 21 | 37 | 24 | 39 | 45 | .43 |
|  | 2 | 11 | 70 | 9 | 10 | 81 | 80 | .00 |
|  | 10 | 10 | 71 | 11 | 8 | 81 | 79 | .06 |
|  | 11 | 15 | 4 | 67 | 13 | 19 | 18 | .00 |
|  | 3 | 15 | 8 | 69 | 9 | 22 | 17 | .76 |
|  | 22 | 17 | 22 | 46 | 15 | 39 | 37 | .04 |
| Part III | 14 | 13 | 28 | 37 | 21 | 42 | 49 | 1.16 |
|  | 26 | 15 | 17 | 55 | 13 | 31 | 30 | .00 |
|  | 18 | 15 | 28 | 46 | 11 | 43 | 39 | .17 |
|  | 7 | 13 | 57 | 19 | 10 | 71 | 67 | .19 |
|  | 8 | 0 | 1 | 99 | 0 | 1 | 1 | --- |
|  | 23 | 8 | 30 | 47 | 15 | 38 | 45 | 1.25 |
|  | 4 | 7 | 80 | 6 | 8 | 87 | 88 | .00 |
|  | 19 | 10 | 69 | 11 | 10 | 79 | 79 | .12 |
|  | 12 | 13 | 10 | 62 | 15 | 24 | 25 | .00 |
|  | 15 | 8 | 60 | 16 | 17 | 67 | 76 | 2.23 |

[a]Percentage of Math 1314 students agreeing with item only on initial presentation

[b]Percentage of Math 1314 students agreeing with item both on initial presentation and terminal presentation

[c]Percentage of Math 1314 students not agreeing with item on both initial presentation and terminal presentation

[d]Percentage of Math 1314 students agreeing with item only on terminal presentation

[e]McNemar test used, if appropriate. --- indicates Binomial test used when McNemar test not appropriate

[#]Significance at the .10 level

presentations and that the per cent of agreement with this statement increased from 29 per cent on the initial presentation to 16 per cent on the terminal presentation.

Table VI reports that 71 per cent disagreed with statement 11--Mathematics (algebra, geometry, etc.) is not useful for problems of everyday life--on both presentations and 74 per cent disagreed with statement 3--Outside of sciences and engineering, there is little place for mathematics (algebra, geometry, etc.) in most jobs--on both presentations.

There was an increase from 35 per cent initially to 48 per cent terminally who agreed with statement 14--A thorough knowledge of advanced mathematics is a key to an understanding of our world in the twentieth century--, while there was a decrease from 42 per cent who agreed initially to 29 per cent who agreed terminally to statement 18--It is important to know mathematics (algebra, geometry, etc.) in order to get a good job--.

It is noted that 100 per cent of the students in $E_1$ disagreed with statement 8--I dislike school and will leave it as soon as possible--on both presentations and that 68 per cent disagreed with statement 12--School is not very enjoyable, but I can see value in getting a good education--on both presentations. Ninety per cent agreed with statement 4--I generally like my schoolwork--on both presentations, 71 per cent agreed with statement 19--I find school interesting and challenging--on both presentations and 65 per cent agreed with statement 15--Although school is difficult, I want as much education as I can get--on both presentations.

There was a change from 32 per cent who agreed initially to 48 per

cent who agreed terminally with statement 23--Most school work is the memorizing of information--.

## Aichele Attitude Scale for $E_2$

Categorical percentages can be found in Table VII. Table VII indicates that only item 24--Almost all students can learn mathematics if properly taught--showed a significant change (.10 level) and this change was in a positive direction, with 56 per cent of the students agreeing on the initial presentation and 76 per cent agreeing on the terminal presentation. Other observations taken from Table VII are presented below.

Table VII reports that 96 per cent disagreed with statement 9-- Very few people can learn mathematics--on both presentations and 84 per cent disagreed with statement 27--Only people with a special talent can learn mathematics--on both presentations, with item 27 exhibiting an increase from 4 per cent initial agreement to 16 per cent terminal agreement. Item 16--Any person of average intelligence can learn to understand a good deal of mathematics--showed 64 per cent agreement on both presentations and also exhibited a change from 72 per cent initial agreement to 84 per cent terminal agreement. Agreement on item 5-- Anyone can learn mathematics--increased from 40 per cent agreement on the initial presentation to 48 per cent agreement on the terminal presentation. Agreement decreased from 60 per cent on initial presentation to 56 per cent on terminal presentation for item 20-- Mathematics can be made understandable and useful to every college student--.

With respect to Part II of the Aichele Attitude Scale, Table VII

indicates that 72 per cent disagreed with item 21--There is little place for originality in mathematics--on both presentations and item 21 also showed a decrease from 24 per cent who agreed initally to only 12 per cent who agreed terminally. 64 per cent disagreed with item 13 --Almost all present-day mathematics was known at least a century ago-- on both presentations and this item showed an increase from 16 per cent who agreed initially to 32 per cent who agreed terminally.

There was an increase from 44 per cent who agreed with item 6-- Mathematics helps one think according to strict rules--initially to 60 per cent who agreed terminally. Items 2--In mathematics there is always a rule to follow in solving problems--and 10--Mathematics helps one develop a good sense of logic--had 80 per cent and 84 per cent, respectively, who agreed with the statements on both presentations. There were increases from initial to terminal presentations for both items with both items increasing from 84 per cent to 92 per cent.

Part III showed that 72 per cent on item 11--Mathematics, (algebra, geometry, etc.) is not useful for problems of everyday life--and 68 per cent on item 3--Outside of the sciences and engineering, there is little place for mathematics (algebra, geometry, etc.) in most jobs--disagreed on both the initial and terminal presentations.

Although not significant, there was an increase from 32 per cent who agreed initially to 52 per cent who agreed terminally on item 18-- It is important to know mathematics (algebra, geometry, etc.) in order to get a good job--. Item 7--Mathematics is of great importance to a country's development--had 72 per cent agreement on both presentations.

The results concerning Part IV show that 96 per cent of the students in $E_2$ disagreed with item 8--I dislike school and will leave

it as soon as possible--on both presentations.  Table VII also indicates

that items 4--I generally like my school work--, 19--I find school in-

teresting and challenging--and 15--Although school is difficult, I want

as much education as I can get--had 72 per cent, 64 per cent and 64 per

cent, respectively, who agreed on both presentations.  Furthermore,

item 4 showed an increase from 80 per cent who initially agreed to 88

per cent who agreed on the terminal presentation and item 19 showed an

increase from 72 per cent who agreed initially to 84 per cent who

agreed terminally.  Item 12--School is not very enjoyable, but I can

see value in getting a good education--also reported an increase from

24 per cent who agreed initially to 32 per cent who agreed terminally.

### Aichele Attitude Scale for C

Categorical percentages can be found in Table VIII.  Table VIII

indicates that there were no significant differences between initial

presentation and terminal presentation for any of the items on the

Aichele Attitude Scale with respect to C, however, other observations

from Table VIII are discussed below.

Item 9--Very few people can learn mathematics--had 100 per cent

disagreement on both the initial and terminal presentations, while

item 27--Only people with a special talent can learn mathematics--had

88 per cent disagreement on both presentations.

Item 16--Any person of average intelligence can learn to under-

stand a good deal of mathematics--had 70 per cent agreement on both pre-

sentations and also exhibited a decrease from 88 per cent who agreed

initially to 76 per cent who agreed terminally.  Item 24--Almost all

students can learn mathematics if it is properly taught--had 82 per

cent who agreed initially but only 70 per cent who agreed on the terminal presentation. Item 5--Anyone can learn mathematics--had an increase from 39 per cent initial agreement to 48 per cent terminal agreement.

Items 21--There is little place for originality in mathematics--and 13--Almost all present-day mathematics was known at least a century ago--had 76 per cent and 70 per cent, respectively, who disagreed on both presentations. Items 2--In mathematics there is always a rule to follow in solving problems--and 10--Mathematics helps one develop a good sense of logic--had 70 per cent agreement on both presentations, but there was a decrease from 85 per cent initial agreement to 76 per cent terminal agreement on item 10. Item 17--Mathematics is a good field for creative people to enter--showed an increase from 39 per cent who agreed initially to 58 per cent who agreed terminally.

With regard to Part III, 64 per cent disagreed on both presentations of item 3--Outside of sciences and engineering, there is little place for mathematics (algebra, geometry, etc.) in most jobs--and there was also a drop from 27 per cent who agreed initially to only 12 per cent who agreed terminally on this item. Item 14--A thorough knowledge of advanced mathematics is a key to an understanding of our world in the twentieth century--showed an increase from 39 per cent who agreed on the initial presentation to 48 per cent who agreed on the terminal presentation, but items 18--It is important to know mathematics (algebra, geometry, etc.) in order to get a good job--and 7--Mathematics is of great importance to a country's development--had decreases from 52 per cent and 76 per cent who agreed initially to 39 per cent and 66 per cent, respectively, who agreed on the terminal presentation.

Item 8--I dislike school and will leave it as soon as possible--
showed 100 per cent of the students in C disagreeing on both presenta-
tions. Item 4--I generally like my school work--had 76 per cent agree-
ment on both presentations and item 19--I find school interesting and
challenging--had 70 per cent agreement on both presentations. However,
item 19 had a drop from 82 per cent who agreed initially to 70 per cent
who agreed terminally. Item 15--Although school is difficult, I want
as much education as I can get--enjoyed an increase from 64 per cent
who agreed on the initial presentation to 73 per cent who agreed on the
terminal presentation.

## Aichele Attitude Scale for Math 1314

Categorical percentages can be found in Table IX. Table IX in-
dicates that only item 5--Anyone can learn mathematics--reported signi-
ficance of change (.10 level) by showing an increase from 38 per cent
who agreed initially to 49 per cent who agreed terminally. Further
observations from Table IX are discussed below.

Items 9--Very few people can learn mathematics--, 27--Only people
with a special talent can learn mathematics--and 1--Most work in mathe-
matics is the memorizing of information--reported 96 per cent, 90 per
cent and 51 per cent disagreement, respectively, on both the initial
and terminal presentations of the scale. Items 20--Mathematics can be
made understandable and useful to every college student--, 16--Any
person of average intelligence can learn to understand a good deal of
mathematics--and 24--Almost all students can learn mathematics if it
is properly taught--had 51 per cent, 63 per cent and 64 per cent agree-
ment, respectively, on both presentations of the scale.

Concerning Part II, 67 per cent disagreed on both presentations of item 21--There is little place for originality in mathematics--with 24 per cent agreeing on the initial presentation and 17 per cent agreeing on the terminal presentation. 65 per cent disagreed on both presentations of item 13--Almost all present-day mathematics was known at least a century ago--with 21 per cent agreeing on the initial presentation and 26 per cent agreeing terminally. Item 25--Mathematics will change rapidly in the future--had 62 per cent disagreement on both presentations.

Items 2--In mathematics there is always a rule to follow in solving problems--and 10--Mathematics helps one develop a good sense of logic--had 70 per cent and 71 per cent agreement, respectively, on both presentations.

Items 17--Mathematics is a good field for creative people to enter-- and 6--Mathematics helps one think according to strict rules-- had increases from 36 per cent and 39 per cent on the initial presentation to 46 per cent and 45 per cent, respectively, on the terminal presentation.

Part III had 67 per cent, 69 per cent and 55 per cent disagreement on both presentations of items 11--Mathematics (algebra, geometry, etc.) is not useful for purposes of everyday life--, 3--Outside of sciences and engineering there is little place for mathematics (algebra, geometry, etc.) in most jobs--and 26--In the near future most jobs will require knowledge of advanced mathematics--, respectively. Item 3 showed a decrease from 22 per cent who agreed initially to 17 per cent who agreed terminally.

Item 7--Mathematics is of great importance to a country's

development--had 57 per cent agreement on both presentations, and item 14--A thorough knowledge of advanced mathematics is a key to an understanding of our world in the twentieth century--showed an increase from 42 per cent who agreed initially to 49 per cent who agreed terminally.

With regard to Part IV, item 8--I dislike school and will leave it as soon as possible--had 99 per cent disagreement on both presentations while item 12--School is not very enjoyable, but I can see value in getting a good education--had 62 per cent disagreement on both presentations.

Items 4--I generally like my school work--, 19--I find school interesting and challenging--and 15--Although school is difficult, I want as much education as I can get--had 80 per cent, 69 per cent and 60 per cent agreement, respectively, on both presentations. Item 15 showed an increase from 67 per cent who agreed initially to 76 per cent who agreed terminally, while item 23--Most school work is the memorizing of information--had an increase from 38 per cent initial agreement to 45 per cent terminal agreement.

A summary of the results of the McNemar test can be found in Chapter V.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS AND

SUGGESTIONS FOR FURTHER STUDY

## Introduction

This section contains the summary, conclusions and implications
related to this investigation and some suggestions for further study.
Briefly, the topics discussed in the preceding chapters are reviewed
in the next paragraph.

The statement of the problem, hypotheses, importance of the study,
assumptions, limitations, and definition of terms were presented in
Chapter I.  Chapter II contained reviews of literature related to
attitudes and methods of presentation.  Chapter III described the ex-
perimental design, sample, measuring instruments, collection of the
data and treatment of the data.  Chapter IV described the results of
the data as interpreted by analysis of covariance, Wilcoxen test, Sign
test and McNemar test.

## Statement of the Problem

Recently more emphasis has been placed upon measurement in the
affective domain; as a result, the assessment of attitudes is consider-
ed an important function of education.  To some extent, it is now
accepted that what a person is or may become, whether he succeeds or
fails, whether he approaches his potential or allows his talents to be

underdeveloped, depends upon the attitudes that person has acquired and the view he has of himself with respect to his environment. This emphasis on attitudes is as important in mathematics as it is in any other discipline. There is also evidence that individuals scoring high on mathematical attitude scales tend to be more socially and intellectually mature, more self-controlled, and have more theoretical interests than individuals scoring low on the scale (4).

The improvement of attitudes, if such a thing can be accomplished, is always worthy of attainment in educational realms, especially if at the same time there is evidence of improvement in achievement. A more eloquent point was made by Anatole France in 1918 as he said:

> It is only by amusing oneself that one can learn.
> The whole art of teaching is only the art of awakening
> the natural curiosity of young minds for the purpose of
> satisfying it afterwards; and curiosity itself can be
> vivid and wholesome only in proportion as the mind is
> contented and happy. Those acquirements crammed by force
> into the minds of children simply clog and stifle intelli-
> gence. In order that knowledge be properly digested, it
> must have been swallowed with a good appetite (26, p. 198).

The emphasis on attitudes is not to imply that the importance of achievement is to be lessened. Our very societal structure places priorities on achievement, hence, maintaining a proper level of achievement is also a major task for any instructional system in mathematics. However, the assessment of attitudes toward mathematics would clearly be of less concern if attitudes were not thought to affect performance in some way. We note that this relationship is one of reciprocity in that achievement also will probably affect attitudes (55).

Specifically, the objectives of this research are to answer the following questions:

A. Which of three methods of teaching Math 1314 is significantly

better with respect to modifying achievement?

B.  Which of three methods of teaching Math 1314 is significant-
ly better with respect to modifying attitudes toward mathematics
(general)?

C.  Does Math 1314 contribute to changes in students' attitudes
toward mathematics (general)?

D.  Does Math 1314 contribute to changes in students' attitudes
toward each of the following areas related to mathematics:  (1) the
learning of mathematics, (2) mathematics as a process, (3) the place
of mathematics in society, and (4) school and learning generally?

E.  Which of three methods of teaching Math 1314 is significant-
ly better with respect to modifying students' attitudes toward each
of the following:  (1) the learning of mathematics, (2) mathematics as
a process, (3) the place of mathematics in society, and (4) school and
learning generally?

## Hypotheses

The hypotheses are arranged according to the five areas described
in the preceding section.  For purposes of statistical treatment, the
hypotheses are reported in the null form.

A.  $H_1$:   There is no significant difference between
method used in the discussion sections and
resulting achievement of students enrolled
in Math 1314.

B.  $H_2$:   There is no significant difference between
method used in the discussion sections and
resulting attitudes toward mathematics
(general) of the students enrolled in
Math 1314.

C.  $H_3$:   There is no significant difference between
initial attitudes of students in Group $E_1$

toward mathematics (general) and terminal
attitudes of students in Group $E_1$ toward
mathematics (general).

$H_4$: There is no significant difference between
initial attitudes of students in Group $E_2$
toward mathematics (general) and terminal
attitudes of students in Group $E_2$ toward
mathematics (general).

$H_5$: There is no significant difference between
initial attitudes of students in Group C
toward mathematics (general) and terminal
attitudes of students in Group C toward
mathematics (general).

$H_6$: There is no significant difference between
initial attitudes of students enrolled in
Math 1314 toward mathematics (general) and
terminal attitudes of students enrolled in
Math 1314 toward mathematics (general).

D.    $H_7$: There is no significant difference between
initial attitudes of students in Group $E_1$
concerning the learning of mathematics
and terminal attitudes of students in
Group $E_1$ concerning the learning of mathe-
matics.

$H_8$: There is no significant difference between
initial attitudes of students in Group $E_2$
concerning the learning of mathematics and
terminal attitudes of students in Group $E_2$
concerning the learning of mathematics.

$H_9$: There is no significant difference between
initial attitudes of students in Group C
concerning the learning of mathematics and
terminal attitudes of students in Group C
concerning the learning of mathematics.

$H_{10}$: There is no significant difference between
initial attitudes of students enrolled in
Math 1314 concerning the learning of mathe-
matics and terminal attitudes of students
enrolled in Math 1314 concerning the learn-
ing of mathematics.

$H_{11}$: There is no significant difference between
initial attitudes of students in Group $E_1$
concerning mathematics as a process and
terminal attitudes of students in Group $E_1$
concerning mathematics as a process.

$H_{12}$: There is no significant difference between initial attitudes of students in Group $E_2$ concerning mathematics as a process and terminal attitudes of students in Group $E_2$ concerning mathematics as a process.

$H_{13}$: There is no significant difference between initial attitudes of students in Group C concerning mathematics as a process and terminal attitudes of students in Group C concerning mathematics as a process.

$H_{14}$: There is no significant difference between initial attitudes of students enrolled in Math 1314 concerning mathematics as a process and terminal attitudes of students enrolled in Math 1314 concerning mathematics as a process.

$H_{15}$: There is no significant difference between initial attitudes of students in Group $E_1$ concerning the place of mathematics in society and terminal attitudes of students in Group $E_1$ concerning the place of mathematics in society.

$H_{16}$: There is no significant difference between initial attitudes of students in Group $E_2$ concerning the place of mathematics in society and terminal attitudes of students in Group $E_2$ concerning the place of mathematics in society.

$H_{17}$: There is no significant difference between initial attitudes of students in Group C concerning the place of mathematics in society and terminal attitudes of students in Group C concerning the place of mathematics in society.

$H_{18}$: There is no significant difference between initial attitudes of students enrolled in Math 1314 concerning the place of mathematics in society and terminal attitudes of students enrolled in Math 1314 concerning the place of mathematics in society.

$H_{19}$: There is no significant difference between initial attitudes of students in Group $E_1$ concerning school and learning generally and terminal attitudes of students in

Group $E_1$ concerning school and learning generally.

$H_{20}$: There is no significant difference between initial attitudes of students in Group $E_2$ concerning school and learning generally and terminal attitudes of students in Group $E_2$ concerning school and learning generally.

$H_{21}$: There is no signficant difference between initial attitudes of students in Group C concerning school and learning generally and terminal attitudes of students in Group C concerning school and learning generally.

$H_{22}$: There is no significant difference between initial attitudes of students enrolled in Math 1314 concerning school and learning generally and terminal attitudes of students enrolled in Math 1314 concerning school and learning generally.

$H_{23}$: There is no significant difference between method used in the discussion sections and resulting attitudes of students toward the learning of mathematics.

$H_{24}$: There is no significant difference between method used in the discussion sections and resulting attitudes of students toward mathematics as a process.

$H_{25}$: There is no significant difference between method used in the discussion sections and resulting attitudes of students toward the place of mathematics in society.

$H_{26}$: There is no significant difference between method used in the discussion sections and resulting attitudes of students toward school and learning generally.

## Summary

The summary of findings are presented according to the five areas outlined in the statement of the problem.

A. Summary of findings derived from the achievement test revealed

that hypothesis $H_1$ was rejected at the .10 level of significance. That is, there is a significant difference between the methods used in the discussion sections and resulting achievement of students enrolled in Math 1314.  The Student $\underline{t}$-test based on adjusted posttest means verified that $E_1$ and C, and $E_2$ and C differed significantly.

B.  Hypothesis $H_2$ could not be rejected at the .10 level of significance.  That is, there is no significant difference between method used in the discussion sections and resulting attitudes toward mathematics (general) of the students enrolled in Math 1314.

C.  Wilcoxen test results reveal that hypotheses $H_3$ and $H_4$ could not be rejected at the .10 level of significance.  That is, there is no significant difference between initial attitudes of students in Group $E_1$ toward mathematics (general) and terminal attitudes of students in Group $E_1$ toward mathematics (general), and there is no significant difference between initial attitudes of students in Group $E_2$ toward mathematics (general) and terminal attitudes of students in Group $E_2$ toward mathematics (general).

Wilcoxen test results also revealed that hypotheses $H_5$ and $H_6$ were rejected at the .10 level of significance.  That is, there is a significant difference between initial attitudes of students in Group C toward mathematics (general) and terminal attitudes of students in Group C toward mathematics (general), and there is a significant difference between initial attitudes of students enrolled in Math 1314 toward mathematics (general) and terminal attitudes of students enrolled in Math 1314 toward mathematics (general).  Furthermore, the data revealed that students in C and Math 1314 exhibited significantly more positive attitudes toward mathematics (general) on the terminal

presentation of the Aiken Attitude Scale than on its initial presentation.

C. Sign test results indicate that hypotheses $H_7$, $H_8$, $H_{10}$ - $H_{15}$, $H_{17}$ and $H_{18}$ could not be rejected at the .10 level of significance. That is, (1) there is no significant difference between initial attitudes of students in Group $E_1$ concerning the learning of mathematics and terminal attitudes of students in Group $E_1$ concerning the learning of mathematics, (2) there is no significant difference between initial attitudes of students in Group $E_2$ concerning the learning of mathematics and terminal attitudes of students in Group $E_2$ concerning the learning of mathematics, (3) there is no significant difference between initial attitudes of students enrolled in Math 1314 concerning the learning of mathematics and terminal attitudes of students enrolled in Math 1314 concerning the learning of mathematics, (4) there is no significant difference between initial attitudes of students in Group $E_1$ concerning mathematics as a process and terminal attitudes of students in Group $E_1$ concerning mathematics as a process, (5), there is no significant difference between initial attitudes of students in Group $E_2$ concerning mathematics as a process and terminal attitudes of students in Group $E_2$ concerning mathematics as a process, (6) there is no significant difference between initial attitudes of students in Group C concerning mathematics as a process and terminal attitudes of students in Group C concerning mathematics as a process, (7) there is no significant difference between initial attitudes of students enrolled in Math 1314 concerning mathematics as a process and terminal attitudes of students enrolled in Math 1314 concerning mathematics as a process, (8) there is no significant difference between initial

attitudes of students in Group $E_1$ concerning the place of mathematics
in society and terminal attitudes of students in Group $E_1$ concerning
the place of mathematics in society, (9) there is no significant dif-
ference between initial attitudes of students in Group C concerning
the place of mathematics in society and terminal attitudes of students
in Group C concerning the place of mathematics in society, and (10)
there is no significant difference between initial attitudes of
students enrolled in Math 1314 concerning the place of mathematics in
society and terminal attitudes of students enrolled in Math 1314 con-
cerning the place of mathematics in society.

Sign test results also revealed that hypotheses $H_9$, $H_{16}$, and $H_{19}$ -
$H_{22}$ were rejected at the .10 level of significance. That is, (1)
there is a significant difference between initial attitudes of students
in Group C concerning the learning of mathematics and terminal atti-
tudes of students in Group C concerning the learning of mathematics,
with more negative attitudes toward the learning of mathematics ex-
hibited on the terminal presentation, (2) there is a significant dif-
ference between initial attitudes of students in Group $E_2$ concerning
the place of mathematics in society and terminal attitudes of students
in Group $E_2$ concerning the place of mathematics in society, with more
positive attitudes toward the place of mathematics in society exhibited
on the terminal presentation, (3) there is a significant difference
between initial attitudes of students in Group $E_1$ concerning school and
learning generally and terminal attitudes of students in Group $E_1$ con-
cerning school and learning generally, with more positive attitudes
toward school and learning generally exhibited on the terminal presenta-
tion, (4) there is a significant difference between initial attitudes

of students in Group $E_2$ concerning school and learning generally and
terminal attitudes of students in Group $E_2$ concerning school and learn-
ing generally, with more positive attitudes toward school and learning
generally exhibited on the terminal presentation, (5) there is a
significant difference between initial attitudes of students in Group
C concerning school and learning generally and terminal attitudes of
students in Group C concerning school and learning generally, with more
positive attitudes toward school and learning generally exhibited on
the terminal presentation, and (6) there is a significant difference
between initial attitudes of students enrolled in Math 1314 concerning
school and learning generally and terminal attitudes of students en-
rolled in Math 1314 concerning school and learning generally, with
more positive attitudes toward school and learning generally exhibited
on the terminal presentation.

McNemar test results indicated that two individual statements in
the Aichele Attitude Scale did reflect significant changes in atti-
tudes at the .10 level of significance.

Statement 24--Almost all students can learn mathematics if
properly taught--showed a significant change in $E_2$, with 56 per cent
of the students in $E_2$ agreeing on the initial presentation and 76 per
cent agreeing on the terminal presentation, and Statement 5--Anyone
can learn mathematics--showed a significant change in Math 1314 with
38 per cent of the students enrolled in Math 1314 agreeing on the
initial presentation and 49 per cent agreeing on the terminal pre-
sentation.

E.  Hypotheses $H_{23}$ - $H_{26}$ could not be rejected at the .10 level of
significance.  That is, (1) there is no significant difference between

method used in the discussion sections and resulting attitudes of students toward the learning of mathematics, (2) there is no significant difference between method used in the discussion sections and resulting attitudes of students toward mathematics as a process, (3) there is no significant difference between method used in the discussion sections and resulting attitudes of students toward the place of mathematics in society, and (4) there is no significant difference between method used in the discussion sections and resulting attitudes of students toward school and learning generally.

## Conclusions and Implications

The conclusions and implications are presented according to the five areas described in the statement of the problem.

A. Considering the results of the analysis testing hypothesis $H_1$, it is concluded that with respect to improving achievement in future Math 1314 classes taught in a format similar to the format used in this study, it would be wise to give one quiz per week. Whether or not the quiz would be used as input in determining students' final grades would not matter, although perhaps the results indicate that higher achievement would be possible if the quiz would not be used as input in determining the final grade.

B. The analysis testing hypothesis $H_2$ implies that the methods used in the discussion sections are essentially equivalent with respect to modification of students' attitudes toward mathematics (general).

C. The Wilcoxen test results, testing hypotheses $H_3$ - $H_6$, suggests that attitudes toward mathematics (general) can be changed in a class. However, it was unexpected that C would exhibit a significant change in

attitudes toward mathematics (general), and possibly, because this group did not have weekly quizzes, more time was provided for the students in C to analyze and understand mathematics, and these students were removed from the anxieties of quizzing.

D. The results of the Sign test, testing hypotheses $H_7$ - $H_{22}$ indicate that it was possible, under differing conditions, to change students' attitudes toward the learning of mathematics, the place of mathematics in society and school and learning generally, but it was not possible to change students' attitudes toward mathematics as a process. This conclusion is both depressing and exhilarating.

This information is depressing when it is seen that not only were attitudes toward mathematics as a process not changed, but they actually veered in a negative direction. Enhancing attitudes toward mathematics as a process is perhaps an essential ingredient in establishing the continuance of Math 1314 as a valid entry in the curriculum for Arts and Sciences students at Oklahoma State University.

The information is exhilarating when one considers that there were changes in students' attitudes toward the learning of mathematics, the place of mathematics in society and school and learning generally, with all groups, $E_1$, $E_2$, C and Math 1314 portraying changes in attitudes toward school and learning generally. However, there are many influences, including the present state of the nation, that could be responsible for the change in attitudes toward school and learning generally. The author believes that, historically, periods of large unemployment have created feelings among people that education is beneficial.

Another conclusion arises from Table V. Table V indicates that

only $E_2$ had more positive terminal attitudes on each part of the Aichele Attitude Scale. If more positive terminal attitudes are desired, then perhaps the method used in the discussion section for $E_2$ could be the vehicle for this attainment.

There was a significant increase in the proportion of students in $E_2$ who believed that almost all students can learn mathematics if it is properly taught. From a pedagogical point of view, this would seem to be encouraging, and it does seem to mesh with the results found concerning students' attitudes toward mathematics as a process. Perhaps it indicates that students view mathematics from an algorithmic point of view, in which the teacher performs "tricks" and thus can teach mathematics properly. If so, perhaps this should not be considered an encouraging sign.

There was a significant increase in the proportion of Math 1314 students who believed that anyone can learn mathematics. An encouraging conclusion from this is that perhaps students have gained some confidence in their ability to learn mathematics.

It was anticipated that more students would conceive of mathematics as a field for creative people to enter, with emphasis placed on originality and a good sense of logic. However, findings on the item change analysis of Part II (Attitudes Toward Mathematics as a Process) of the Aichele Attitude Scale suggest that creative aspects of mathematics were not explored to the desired extent, or that the definition of creativity in mathematics varies according to the knowledge one has of the structural organization of mathematics.

It was noted that large proportions (greater than 90 per cent) of students in Math 1314 disagreed that very few people can learn

mathematics and also disagreed that they disliked school and would leave it as soon as possible.

In summary, the conclusions mentioned above would appear to imply that people think that mathematics is "learnable" and that they do not have intense dislike of learning, so that mathematics teachers do have an opportunity to enhance mathematics enrollments by providing appropriate methods that make mathematics relevant, which implies that the teachers should also locate and use better methods of teaching mathematics.

E. The results of the analysis regarding hypotheses $H_{23}$ - $H_{26}$ indicate that the methods used in the discussion sections did not differ with respect to modification of students' attitudes toward the learning of mathematics, mathematics as a process, the place of mathematics in society, and school and learning generally.

## Suggestions for Further Study

This section presents a discussion of further investigations that are possible but which were beyond the scope of this study.

Since this study is an extension of previous work formulated in the areas of attitudes (2), it would appear that a comparison of the results obtained previously with the results of this study would be in order. One of the most interesting questions that arises is whether the statements of the Aichele Attitude Scale were as appropriately scaled for this study as they were for the previous study (2).

Because of the various instruments used in this study to investigate attitudes toward areas relating to mathematics, it would be appropriate to ascertain in what manner the scores of initial and

terminal presentation on each scale correlate. It would be informative to see how the scores of initial and terminal presentation on each attitude scale correlates with the initial and terminal presentation of the Achievement test. Perhaps "enhancing" achievement, based on the scales used in this study, is in contradiction to "enhancing" attitudes toward the areas related to mathematics as measured in this study.

A more detailed study of factors why a student likes or dislikes mathematics would be more beneficial than just having a score that measures a students' attitude toward an area related to mathematics.

Since Math 1314 is usually a terminal mathematics course, it would be appropriate to decide if there would be an optimal time in the student's academic areer in which Math 1314 would be most beneficial, or if there is a method of predicting whether a student will be successful in Math 1314.

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APPENDIX A

ATTITUDE SURVEY

OKLAHOMA STATE UNIVERSITY

NAME_____ I.D. NUMBER_____

A.  LISTED BELOW ARE A NUMBER OF STATEMENTS.  PLEASE INDICATE HOW
    WELL THESE STATEMENTS APPLY TO YOU BY CIRCLING A NUMBER FOR
    EACH STATEMENT.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Somewhat Agree | Neither Agree Nor Disagree | Somewhat Disagree | Strongly Disagree |

1.  I am always under a terrible strain
    in a mathematics class.                     1    2    3    4    5

2.  I do not like mathematics, and it
    scares me to have to do it.                 1    2    3    4    5

3.  Mathematics is very interesting to
    me, and I enjoy arithmetic and
    mathematics courses.                        1    2    3    4    5

4.  Mathematics is fascinating and fun.         1    2    3    4    5

5.  Mathematics makes me feel secure, and
    at the same time it is stimulating.         1    2    3    4    5

6.  My mind goes blank and I am unable to
    think clearly when working mathe-
    matics.                                     1    2    3    4    5

7.  I feel a sense of insecurity when
    attempting mathematics.                     1    2    3    4    5

8.  Mathematics makes me feel uncomfort-
    able, restless, irritable, and
    impatient.                                  1    2    3    4    5

9.  The feeling that I have toward
    mathematics is a good feeling.              1    2    3    4    5

10. Mathematics makes me feel as though
    I'm lost in a jungle of numbers and
    can't find my way out.                      1    2    3    4    5

11. Mathematics is something that I
    enjoy a great deal.                         1    2    3    4    5

12. When I hear the word "mathematics"
    I have a feeling of dislike.                1    2    3    4    5

13. I approach mathematics with a feeling
    of hesitation, resulting from a fear
    of not being able to do mathematics.    1   2   3   4   5

14. I really like mathematics.              1   2   3   4   5

15. Mathematics is a course in school
    that I have always enjoyed studying.    1   2   3   4   5

16. It makes me nervous to even think
    about having to do a mathematics
    problem.                                1   2   3   4   5

17. I have never liked mathematics,
    and it is my most dreaded subject.      1   2   3   4   5

18. I am happier in a mathematics
    class than in any other class.          1   2   3   4   5

19. I feel at ease in mathematics
    and I like it very much.                1   2   3   4   5

20. I feel a definite positive reaction
    toward mathematics; it's enjoyable.     1   2   3   4   5

B.  READ EACH OF THE STATEMENTS GIVEN BELOW. PLACE A CHECK
    IMMEDIATELY TO THE LEFT IN THE SPACE PROVIDED OF THOSE
    STATEMENTS WHICH EXPRESS YOUR PRESENT FEELING TOWARD
    MATHEMATICS.

_____ 1. Most work in mathematics is the memorizing of information.

_____ 2. In mathematics there is always a rule to follow in solving
          problems.

_____ 3. Outside of the sciences and engineering, there is little
          place for mathematics (algebra, geometry, etc.) in most
          jobs.

_____ 4. I generally like my school work.

_____ 5. Anyone can learn mathematics.

_____ 6. Mathematics helps one think according to strict rules.

_____ 7. Mathematics is of great importance to a country's
          development.

_____ 8. I dislike school and will leave it as soon as possible.

_____ 9. Very few people can learn mathematics.

_____10. Mathematics helps one develop a good sense of logic.

_____11. Mathematics (algebra, geometry, etc.) is not useful for problems of everyday life.

_____12. School is not very enjoyable, but I can see value in getting a good education.

_____13. Almost all present-day mathematics was known at least a century ago.

_____14. A thorough knowledge of advanced mathematics is a key to an understanding of our world in the twentieth century.

_____15. Although school is difficult, I want as much education as I can get.

_____16. Any person of average intelligence can learn to understand a good deal of mathematics.

_____17. Mathematics is a good field for creative people to enter.

_____18. It is important to know mathematics (algebra, geometry, etc.) in order to get a good job.

_____19. I find school interesting and challenging.

_____20. Mathematics can be made understandable and useful to every college student.

_____21. There is little place for originality in mathematics.

_____22. Unless one is planning to become a mathematican or scientist, the study of advanced mathematics is not very important.

_____23. Most school work is the memorizing of information.

_____24. Almost all students can learn mathematics if it is properly taught.

_____25. Mathematics will change rapidly in the future.

_____26. In the near future most jobs will require knowledge of advanced mathematics.

_____27. Only people with a special talent can learn mathematics.

APPENDIX B

TABLE X

TABLE X

AICHELE ATTITUDE SCALE STATEMENTS, SCALE VALUES,
AND RELIABILITY COEFFICIENTS

Part I: Views Concerning the Learning of Mathematics.

   9.  Very few people can learn mathematics.
(.000)

  27.  Only people with a special talent can learn
mathematics. (.463)

   1.  Most work in mathematics is the memorizing
of information. (1.107)

   5.  Anyone can learn mathematics. (1.231)

  20.  Mathematics can be made understandable and
useful to every college student. (2.064)

  16.  Any person of average intelligence can
learn to understand a good deal of mathematics. (2.306)

  24.  Almost all students can learn mathematics
if it is properly taught. (2.314)

Reliability coefficient = .3132

Part II. Views Concerning Mathematics as a Process

  21.  There is little place for originality in
mathematics. (.000)

  13.  Almost all present-day mathematics was
known at least a century ago. (.179)

  17.  Mathematics is a good field for creative
people to enter. (.392)

  25.  Mathematics will change rapidly in the
future. (.502)

   6.  Mathematics helps one think according to
strict rules. (1.058)

   2.  In mathematics there is always a rule to
follow in solving problems. (1.106)

TABLE X (continued)

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10. Mathematics helps one develop a good
    sense of logic. (2,643)

Reliability coefficient = .5585

PART III: Views Concerning the Place of Mathematics
in Society

11. Mathematics (algebra, geometry, etc.) is
    not useful for problems of everyday life.
    (.000)

3. Outside of sciences and engineering, there
   is little place for mathematics (algebra,
   geometry, etc.) in most jobs. (.112)

22. Unless one is planning to become a mathe-
    matician or scientist, the study of advanced
    mathematics is not very important. (.185)

14. A thorough knowledge of advanced mathe-
    matics is a key to an understanding of our
    world in the twentieth century. (.887)

26. In the near future most jobs will require
    knowledge of advanced mathematics. (.905)

18. It is important to know mathematics
    (algebra, geometry, etc.) in order to get
    a good job. (.934)

7. Mathematics is of great importance to a
   country's development. (1.226)

Reliability coefficient = .5766

Part IV: Views Concerning School and Learning
Generally

8. I dislike school and will leave it as soon
   as possible. (.000)

23. Most school work is the memorizing of
    information. (1.104)

4. I generally like my school work. (1.354)

19. I find school interesting and challenging.
    (1.532)

TABLE X (continued)

12. School is not very enjoyable, but I can see value in getting a good education. (1.598)

15. Although school is difficult, I want as much education as I can get. (1.902)

Reliability coefficient = .5002

VITA

Melfried Olson

Candidate for the Degree of

Doctor of Education

Thesis:   THE EFFECTS OF THREE METHODS OF INSTRUCTION ON
          ACHIEVEMENT AND ATTITUDES IN GENERAL COLLEGE
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