1969

A Comparison of the Mathematical Achievement Attained Using Two Methods of Teaching First Year Algebra to Alaskan Native High School Students

Jerry E. Burgett
Central Washington University

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A COMPARISON OF THE MATHEMATICAL ACHIEVEMENT ATTAINED USING TWO METHODS OF TEACHING FIRST YEAR ALGEBRA TO ALASKAN NATIVE HIGH SCHOOL STUDENTS

A Thesis

Presented to

The Graduate Faculty

Central Washington State College

In Partial Fullfillment

of the Requirements for the Degree

Master of Education

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by

Jerry E. Burgett

July 1969

APPROVED FOR THE GRADUATE FACULTY

John E. Davis, COMMITTEE CHAIRMAN

Gerald E. Hosman

Roy F. Ruebel

ACKNOWLEDGMENTS

Special appreciation is extended to Dr. John E. Davis for his counsel, constructive criticism, and supervision in directing the writing of this study.

Acknowledments are also due Dr. Roy F. Ruebel and Mr. Gerald E. Hosman for their encouragement and service on the Thesis Committee.

Finally, the writer is grateful to his wife, Mary, who typed the thesis and to Denise, Danny, Marsha, and Jimi Marie for their patience, understanding, and assistance in bringing this study to completion.

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

A heavy burden has been imposed upon our educational resources by the rapid rate of technological and scientific advancement. Within the past twenty-five years, the American people have made important strides toward understanding the building blocks of life, toward harnessing nuclear energy, and toward the exploration of outer space.

Science education has been in an era of energetic reconstruction and reform for more than a decade.

It was the launching of the first Soviet earth satellite, Sputnik 1, in 1957, which gave great impetus to the reform movement by drawing the attention of many non-scientists to the pressing need for expanded efforts. However, important projects for improving mathematics education were already moving ahead before Sputnik 1. One project was started in 1952 by a group of mathematicians at the University of Illinois when they began work to develop better instructional materials for school mathematics.

In 1960, at a regional orientation conference in mathematics, G. Bailey Price stated, "The changes in mathematics in progress at the present time are so extensive, so far-reaching in their implications and so profound that they can be described only as a revolution" (18:1). Even though more than eight years have passed since 1960, the revolution in mathematics is still in progress.

The revolution has resulted in the introduction of numerous mathematics programs. These programs, in turn, have stimulated interest in method, in content, and in the learning process. Changes are now appearing in both subject matter content and teaching procedures. Textbook publishers have produced fresh editions, and many school administrators are providing in-service training for their teachers, in an attempt, to encourage the tryout of these new programs.

During the past nine years the writer has tried both the traditional and the modern approaches to teaching first year algebra. This teaching experience aroused interest in the mind of the writer as to whether the traditional approach or the modern approach fosters greater improvement in mathematical achievement.

After reading many articles and research studies pertaining to mathematics, the investigator came to the conclusion that additional research was needed in the area of first year traditional algebra versus first year modern algebra. This opinion and interest gave rise to the following problem and became the impetus for this thesis.

I. THE PROBLEM

Statement of the problem. The major purpose of the study was to compare two different methods of teaching first year algebra to Alaskan Native high school students. The basis for comparison was their effect on mathematical achievement.

This study was based on the null hypothesis that no statistically significant difference would be found in mathematical achievement attained by Alaskan Native high school students taught first year algebra either by the traditional method or the modern method.

Justification of the problem. There has been so much disagreement over the teaching of mathematics that many laymen, teachers, and administrators no longer know which expert is correct. The controversy often leaves the high school teacher and administrator confused as to whether the mathematics curriculum should be based on the "new" or the "old" content.

Many school systems are taking a very critical look at their total mathematics program. Goals, content, and method in relation to students' abilities and needs are being re-examined.

Numerous articles have been written about course content and teaching methods in elementary and secondary school mathematics. However, the writer found very few research studies which compared the achievement effect of traditional textbook algebra I instruction to the achievement effect of modern textbook algebra I instruction.

The lack of adequate research in this area led to this attempt at determining which approach to teaching first year algebra has the greater effect on mathematical achievement. This information should be of value to mathematics supervisors and school administrators because it is their responsibility to provide leadership in establishing the best possible mathematics programs in their schools.

Limitations of the problem. The writer was unable to find a standardized test that appeared to be designed to adequately measure total achievement of students in a modern algebra program. This was seen as a limitation to this study, however, an attempt was made to lessen this limitation by using two modern algebra tests designed by the authors of the textbook used in the modern algebra class. The use of tests designed specifically for the textbook used to teach modern algebra could have given some advantage to the students in the modern algebra group. On the other hand, the writer felt the two tests adequately measured modern algebra achievement.

II. DEFINITIONS OF TERMS USED

For the purpose of this study the following terms were defined as follows:

Traditional method. This method is often regarded as the topic approach because the material is presented as a series of unrelated topics. Emphasis is placed on the teacher telling and demonstrating the facts, and the students practicing for mastery. Little emphasis is placed on concept or personal experience.

Modern method. This method is often regarded as the concept approach because the material is organized around certain selected unifying concepts. Algebra courses using this approach stress the fundamental concepts and unifying themes common to all systems of mathematics. Emphasis is placed on the deductive structure of mathematics.

Alaskan Native. This term refers to persons born in Alaska who are one-fourth or more Indian, Eskimo, or Aleut.

CHAPTER II

REVIEW OF THE LITERATURE

The expression, modern mathematics, was originally used in connection with the content of those branches of mathematics developed since the beginning of the 19th century. Since then, many articles have been written about modern mathematics in the curriculum of the nation's schools. Brother L. Raphael wrote, "Perhaps the greatest service rendered by the introduction of the various programs is the increased interest in method, in content, and in the learning process" (20:15).

I. OVERVIEW OF MODERN MATHEMATICS

The movement to introduce modern mathematics in the curriculum of the nation's schools began with the emphasis on content. James H. Zant stated, "Many things are happening in the field of mathematics and mathematics education. From the standpoint of content mathematics is one of the fastest growing and most radically changing of the sciences" (26:594). Similary, Joseph Stipanowich believes we have a mixture of the old and the new resulting from the increase in the amount of mathematics created in the last fifty years (19:140).

When the expression modern mathematics began to develop unfavorable connotations, many enthusiastic promoters of reform began to disassociate themselves from it by shifting from an emphasis on content to an emphasis on form. For example, Edwin E. Moise, who is also known as James Conant, said:

> . . . To understand what is going on, the first thing that we need to recognize is that while the programs are new and modern, the mathematics contained in them is not. . . . The most important changes have been in the style in which the old content has been formulated and presented (17:1).

Moise's views on content and method are shared by two other mathematicians, Morris Kline and Harold M. Bacon, when they contend that the new feature of modern mathematics is the way in which the old content has been formulated and presented (17:13-17).

The transition from an emphasis on content to an emphasis on form has created much confusion in the minds of the nation's educators. Thus according to Alexander Calandra, ". . . it comes about that the expression 'modern math' is often little more than a status symbol used by mathematicians to obtain grants, educators to gain prestige, and Publishers to sell books. . ." (17:6).

II. MODERN MATHEMATICS PROGRAMS

In recent years, many new programs in mathematics have been developed. Although each program has unique features, all of them share common elements and are aimed at the improvement of mathematics instruction.

Nearly all of the modern mathematics programs attempt to avoid the presentation of new materials as a string of unrelated topics. Instead, they stress unifying themes or ideas in mathematics such as the following:

1. Structure.
2. Measurement.
3. Operations and their inverses.
4. Extensive use of graphical representation.
5. Systems of numberation.
6. Properties of numbers, development of the real number system.
7. Statistical inference, probability.
8. Sets-language and elementary theory.
9. Logical deductions.
10. Valid generalizations (18:22).

First year algebra programs are usually classified as "modern" if they emphasize the structure of mathematics and include all of the following concepts: Commutative, associative, and distributive properties; sets; inequalities; absolute value; and the number line (1:51).

III. CRITICS OF MODERN MATHEMATICS

Kline, an expert in the field of mathematics, comments that other experts who have devised the new mathematics are on the wrong track and headed toward the wrong destination. He specifically objects to the emphasis on the deductive structure in the approach to mathematics. Furthermore, he believes that students in modern mathematics are expected to learn "sterile, peripheral, pedantic details in place of the fruitful and rich essence of mathematics" and that it is "sheer nonsense" to say we need a totally new kind of mathematics. Kline goes on to say that the central issue should be how to present the content of the traditional curriculum and in his opinion the correct approach is constructive and not deductive (17:13).

The theory of sets, according to Kline, is a waste of time in the elementary and high school levels and should be eliminated (17:16). Many other experts share Kline's objection to sets. One of these is R. L. Goodstein who made the following statement:

> The reduction of relations to ordered pairs and then to sets is a technical device of interest in the formulisation [sic] of set theory, but is nonsensical out of its proper setting. . . Proposals as extreme and eccentric as those under review can I fear only serve to damage the case for reform (17:7).

Another critic of the new math, Bernard Friedman, views the new math movement as an effort to teach students the new language of mathematics so they can handle higher mathematics at a later stage in their education. He also believes mathematicians are no longer interested in computation, and it should have been foreseen that "new math" might lead to a deficiency in computational skills (24:66).

The following statement appearing in an article edited by Mortimer Smith seems to agree with Friedman's statement about computional skill as well as with Kline's and Goodstein's view on sets:

> A similar criticism was made last month by "new math" pioneer Max Beberman of the University of Illinois, in an Associated Press interview, he said of grade school programs: "We're not doing a good enough job of teaching masses of children the very, very basic ideas and skills in mathematics--the ability to compute or do arithmetic." A student with insight into computation "is the kind of kid we should be turning out. Instead they are mouthing words like 'cummulative principles'." Beberman emphasized that he was not "deserting the movement, but I am seriously concerned about the crazy turns

> we've taken." He singled out the concept of sets as an example of what has gone wrong; he said, "A trivial piece of subject matter. . . not a clarification at all." He did not favor a return to the old math. "We really need a revolution in math. What has happened is in no way a revolution. It is a superficial readjustment of terms" (24:66).

Saunders MacLane is one expert that believes many of the reforms are good, but that some basic ideas are neglected and, like Kline and Beberman, thinks sets have been overdone. He also says that school mathematics is no longer taught in a fixed pattern, and the introduction of formal rules of symbolic logic below college level is against the weight of mathematical judgment (10:42-43). Similary, David Rappaport contends the new emphasis is bringing sophisticated mathematics to students at too early an age and is violating sound principles of learning theory (21:47-48).

IV. DEFENDERS OF MODERN MATHEMATICS

Howard R. Fehr, in an attempt to defend modern mathematics, contends that unity is one aspect of modern mathematics, that clarity of expression is lacking in traditional textbooks, and that concepts are missing that could put the traditional program in harmony with modern developments. He also has the opinion that first year algebra is becoming a more unified study of number systems, variables, equations, and functions (10:41-42). W. Eugene Fergson agrees with Fehr's opinion on first year algebra and states, ". . . algebra should be taught from the standpoint of structure" (11:144).

According to Dan T. Dawson and William F. McClintock, new mathematics is structured to emphasize "why" as well as "how" (7:16). Clyde G. Corle somewhat agrees with Dawson and McClintock when he states in part:

1. Memorization of meaningless facts has been replaced by reasoning, by the study of principles, postulates, and logic.
2. New mathematics has brought about a more careful use of quantitative vocabulary.
3. Modern mathematics has placed increased emphasis upon understanding of computational operations.
4. Modern mathematics gives the responsibility of learning back to the children (7:244-246).

In addition, Corle criticizes the traditional programs of mathematics because it gives the students who like to think creatively a steady diet of boredom (6:246).

Veryl Schult has the view that teachers and students are making exciting discoveries together in the modern mathematics programs, and that students have a new desire to read and work ahead on their own (23:15).

Zant, in defense of modern mathematics, wrote:

> A modern program in mathematics for secondary schools involves concepts, definitions and ideas with a logical structure of the subject. . . . The new approach leads to understanding on the part of the students as contrasted to a considerable amount of rote memory of both rules of operation and a large number of basic facts when mathematics is taught from the traditional point of view. Skills do not seem to suffer under the new program.
>
> . . . .
>
> We know the use of modern textbooks in mathematics, in the hands of competent teachers, has resulted in better teaching in the classroom. Students have become interested in the subject and are taking more mathematics in high school (25:188-191).

A similar view was revealed in an article written by Herbert

Fremont. In this article Fremont quoted Edwina Deans as making the following statement:

> Principles involved in the commutative, associative, and distributive laws of mathematics are a fundamental part of the newer experimental programs. Through the application and understanding of these principles, children are assisted in developing not only skill but also concepts of the nature of the operations, appreciation for the flexibility which is possible in mathematics, and understandings underlying the algorithms or forms of recording mathematics (12:715).

Paul C. Rosenbloom, another defender of modern mathematics, strongly objects to Kline's criticisms of the new mathematics and was quoted in the New York Times as saying in reference to Professor Kline: "I think it is about time he took some practical, postive action and put up or shut up" (24:61).

V. PREVIOUS RESEARCH

There is a dearth of information pertaining to comparative studies in the area of traditional textbook algebra I instruction versus modern textbook algebra I instruction. The existing research gives little or no information about the value of the so-called "new" topics in mathematics and decisions on the introduction of these programs are usually based on the opinions of educators and/or mathematicians.

Nearly all of the evaluation studies in mathematics compare, by means of traditional tests, the achievement of pupils who studied traditional materials with those who studied the School Mathematics Study Group materials. According to K. E. Brown and T. L. Abell, traditional tests indicated that the students in the new programs learned traditional material (3:54).

During the academic year 1959-1961 the Minnesota National Laboratory conducted studies to determine the effectiveness of the S M S G material for grades 7-12. The major problem was to determine whether or not students in S M S G classes do any worse on standard achievement tests than students in conventional courses.

A summary of the results indicated that students in the S M S G classes did about as well on traditional achievement tests as they might be expected to (22:1). On the other hand, Rosenbloom wrote:

> of the various S M S G texts, the experimental evidence in the 9th grade is the least satisfactory. I find the E T S report confusing and somewhat contradictory. Our results were better the first year than the second. The higher ability students did somewhat worse than one would expect on the basis of their pretest scores. We can't make final comparison because (the real payoff of the S M S G 9th grade course may lie in better preparation for grades 10 and 11, and 12) the test may not have measured adequately the ability to solve "word problems" . . . (22:5).

In a later study, Nicholas Kushta compared two different methods of teaching algebra in the first half of the ninth grade. Using the scores attained on traditional tests, Kushta concluded that there was no statistically significant difference in the degree of manipulative skills developed by students taught either by the concept method or the topic method. However, when the schools were considered individually, one class taught by the topic method did perform manipulative skills significantly better at one center than the class taught by the concept method. A second conclusion was that students taught by the concept or modern method developed a significantly greater understanding of the nature of mathematics as a whole than students taught by the traditional approach (14:142-143).

VI. SUMMARY

One of the purposes of this review of literature was to give examples of some of the issues involved in the controversy of modern mathematics versus traditional mathematics. The experimenter has stated views held by many recognized experts in the field of mathematics. It appears that for every expert in favor of a certain aspect of modern mathematics there is also an expert not in favor of it. Thus, it is understandable why educators no longer know what expert to listen to.

Many of the research studies at the high school level are directly related to modern mathematics. However, very few studies are directly related to the comparison of achievement between students in first year modern algebra and students in first year traditional algebra. The few studies that are related to a comparison of achievement in first year algebra have used traditional tests to determine outcome and give very little information as to the value of modern algebra versus traditional algebra.

Decisions on the introduction of modern algebra are generally based on the opinions of educators and/or mathematicians. Rosenbloom states:

> It is scandalous that, after all the testing that has gone on these many years, we still do not have calibrated measuring instruments, nor do we have any base for comparison of any innovations which may be made (22:2).

CHAPTER III

PROCEDURES USED

The experiment was carried on during the 1967-68 school year in the Bureau of Indian Affairs boarding school at Mount Edgecumbe, Alaska.

Mount Edgecumbe School is a four year accredited high school which enrolls approximately 670 Alaskan Native students from all regions of the state of Alaska. In addition to being an Alaskan Native, the student must have completed the eighth grade and be a resident of a community where no high school facilities are available, or have social or health problems of such a nature that he will be best served by enrollment at a boarding school (15:106).

Applications for admission to Mt. Edgecumbe School are made through the Juneau Area Office. Students are selected, each spring, by educational personnel from the Juneau Area Office and Mount Edgecumbe School. Absence of a local high school is given priority over any other combination of justifications for enrollment.

The students, during the academic school year, are under dormitory supervision with no direct parental contact. Expert medical and dental facilities are available at no expense to the student.

The purpose of the school is threefold: to give the Alaskan Native student an opportunity to gain skills so that he may fulfill his economic needs; to provide the opportunity for the Alaskan Native to acquire a socialization that will enable him to become a participating citizen; to provide experiences and associations that will enable the student to find his place in society.

Mount Edgecumbe School provides a typical high school course of study. In addition to offering a fully accredited high school course of study, a wide variety of exploratory and preliminary courses in vocational training is offered (15:107).

The mathematics program at Mount Edgecumbe School is ungraded. Students must have at least one year of mathematics to meet high school graduation requirements. This requirement may be met either by one year of general mathematics or one year of algebra I. Mathematics courses must be taken in a sequential order: algebra I must be taken before slide rule, geometry, or algebra II; geometry and algebra II must be taken before trigonometry; trigonometry must be taken before calculus. Second year algebra and geometry may be taken during the same school year. At Mount Edgecumbe School, the slide rule, trigonometry, and calculus courses are one semester courses, but general mathematics, algebra I, algebra II, and geometry are two semester courses.

Since the mathematics program is ungraded, any student may enroll in first year algebra. However, if a student's grade placement score is below the ninth grade, he is advised to enroll in general mathematics.

I. THE SUBJECTS

The sample population for this study was randomly selected from one hundred students, at Mount Edgecumbe High School, who indicated their desire to enroll in first year algebra during the 1967-68 school year.

In order to control the number of variables in this study, it was considered necessary to use matched groups. An individual was selected at random from the one hundred students desiring to enroll in first year algebra. Then, from a subset of the remaining individuals who possessed the same measured amounts of the control variables, a second individual was selected at random. This selection process was repeated until twenty-five matched pairs of subjects were obtained. Members of each matched pair were then assigned randomly to the two experimental groups.

All tests used to equate the two groups were administered to the students during the last week in August and the first week in September, 1967. These tests were the _Lee Test of Algebraic Ability_, the mathematics section of _Form W: Advanced California Achievement Test_, and the _California Short-Form Test of Mental Maturity_.

It is considered extremely difficult to equate individuals when using small samples and controlling several possible causes of differences. Therefore, the experimenter decided to allow a variation of two raw points in algebraic ability, five months in mathematics grade placement, eight points deviation in measured intelligence, and twelve months in mental age. However, few variations reached the set limits. (See Table XII, page 43 in the Appendix).

The experimenter had planned to replace members of the traditional algebra group if they had previously studied modern mathematics. This was unnecessary because none of the original twenty-five members had been exposed to modern mathematics.

For the purpose of this study, the group to be taught modern algebra by the modern method was designated as the experimental group (E), while the group to be taught traditional algebra by the traditional method was designated as the control group (C).

II. THE INSTRUCTIONAL PROGRAM

The experiment was conducted in the classroom of the experimenter. Teaching was done in fifty minute periods, five days per week, for thirty-six weeks. The experimental group met fourth period each day and the control group met fifth period each day.

Several precautions were taken to control situations that might influence results. First, in an attempt to eliminate teacher variability, the experimenter taught both groups. The experimenter, however, was transferred to a new position during the second semester of the experiment. This made it necessary to have another experienced teacher teach both groups during the second eighteen weeks of the study. Prior to being transferred, the experimenter oriented the second semester teacher. The purpose of the study was explained, textbooks and lesson plans were discussed, and the new teacher observed several class sessions before he began teaching the two groups. A second precaution was that of soliciting the cooperation of the students in not discussing anything about the experimental program with individuals who were not in their group. Next, students were asked to seek help, on mathematics problems, from the teacher or members of their own group. Finally, a "Do Not Enter" sign was placed on the classroom door during testing.

Previous to 1963, the Mount Edgecumbe School used the 1957 edition of Edgerton and Carpenter's Elementary Algebra by Myron R. White. Since this book was considered a traditional text, it was used in instructing the control group. The experimental group used a 1966 edition of Houghton Mifflin's Modern Algebra Structure and Method by Dolciani, Berman, and Freilich as its main text and a 1961 edition of First Course In Algebra by the School Mathematics Study Group as a supplementary text. Both teachers had previous experience in using the three texts; therefore, the variable of teacher familiarity with the texts was not a major problem.

III. THE COLLECTION OF DATA

Test scores were collected, throughout the study, for the purpose of evaluating mathematical differences that might have developed between the control and experimental groups.

Data were collected on algebraic ability, traditional algebra achievement, modern algebra achievement, total mathematical achievement, knowledge of mathematical facts, ability to analyze problem situations, and skill in mathematical manipulations. (See Tables XIII through XXIII, pages 44-54 in the Appendix).

Three tests were administered to both groups during the eighteenth week of instruction. In addition, five tests were given during the thirty-sixth week of the study.

The first semester tests were the Lee Test of Algebraic Ability, Cumulative Test 14 written for Myron R. White's Elementary Algebra text, and Cumulative Test 20 written for Houghton Mifflin's Modern Algebra Text.

The final or second semester tests were the Lee Test of Algebraic Ability, Form X: Advanced California Achievement Test, Form 4: Elementary Algebra Test copyrighted in 1954 and written by Lyle M. Eakins, Cumulative Test 22 written for White's Elementary Algebra, and a combination of Cumulative Tests 27 and 37 written for Houghton Mifflin's Modern Algebra Text.

Since this study was concerned with randomly selected matched pairs, the experimenter dealt directly with pairs rather than individual subjects. The score of a pair was taken to be the difference (D) between the criterion score for the member of the pair assigned to the control group and the criterion score for the member of the pair assigned to the experimental group.

A test of the hypothesis that the mean of such a population of D-scores is zero is equivalent to a test of the hypothesis of no difference between the means of the two hypothetical populations represented in each of the pairs. Therefore, the t-test was used to determine statistical significance of the mean of the sample of D-values. The formula used to calculate t-scores was $t = (\overline{D}\sqrt{N-1})/s_D$ where:

N = number of D-values (pairs) in the sample.

$\overline{D}$ = the mean of the sample of D-values ($\overline{X}_C - \overline{X}_E$).

s_D = the standard deviation of the sample of D-values.

Statistical significance was determined at the five per cent level of confidence. (See Table XXIV, page 55 in the Appendix).

CHAPTER IV

FINDINGS AND INTERPRETATION OF DATA

In an attempt to answer the question set forth in this study, this chapter contains the findings from a comparative analysis of post-test scores of students in the two matched groups.

Scores were analyzed through the application of the t-test to determine statistically significant differences which might have existed between the control and experimental groups. Statistical significance was determined at the five per cent level of confidence.

The data contained in Table I presents a comparison of the mean scores attained on the Lee Test of Algebraic Ability which was administered during the eighteenth week of study.

TABLE I

MEAN COMPARISON OF LEE TEST OF ALGEBRAIC ABILITY SCORES FOR TWENTY-FIVE MATCHED PAIRS (EIGHTEENTH WEEK TEST)

N	ΣD	$\overline{D}$	$\tilde{s}_D$	Obtained t	Required t
25	+21	+.84	6.90	+.596	2.06

Table I shows that the mean score for the control group exceeded the mean score of the experimental group on the Lee Test of Algebraic Ability given during the eighteenth week of the study. Although the difference between the means was +.84, it was not statistically significant at the five per cent level of confidence.

Table II presents a comparison of mean scores attained by the experimental and control groups on the Lee Test of Algebraic Ability given during the thirty-sixth week of study.

TABLE II

MEAN COMPARISON OF LEE TEST OF ALGEBRAIC ABILITY SCORES FOR TWENTY-FIVE MATCHED PAIRS (THIRTY-SIXTH WEEK TEST)

N	ΣD	$\overline{D}$	σ_D	Obtained t	Required t
25	-3	-.12	5.82	-.101	2.06

Table II shows the Lee Test of Algebra Ability favored the experimental group when it was given to both groups during the thirty-sixth week of instruction. The mean score for the experimental group exceeded the mean score for the control group by .12. This difference (-.12) was in contrast to the difference in mean scores obtained on the eighteenth week Lee Test of Algebraic Ability where the difference (+.84) favored the control group. Even though the t-score changed from +.596 to -.101 between the eighteenth and thirty-sixth weeks of the study, the t-score of -.101 was found to be of no statistical significance at the five per cent level of confidence.

Table III contains a comparison of the mean scores for the control and experimental groups obtained from the modern algebra test given at the end of the first semester. This test was designed, as a first semester cumulative test, by the authors of the Houghton Mifflin Modern Algebra I textbook.

TABLE III

MEAN COMPARISON OF MODERN ALGEBRA I TEST SCORES FOR TWENTY-FIVE MATCHED PAIRS (EIGHTEENTH WEEK TEST)

N	ΣD	$\overline{D}$	$\hat{s}_D$	Obtained t	Required t
25	+6	+.24	2.01	+.585	2.06

Table III indicates that the control group attained higher achievement scores on the eighteenth week modern algebra test. In other words, the experimental group had a smaller mean score on the first semester modern algebra test. The difference resulted in a t-score favorable to the control group. This t-score of +.585 was not statistically significant at the five per cent level of confidence.

Table IV contains a comparison of the mean scores for the control and experimental groups resulting from the modern algebra test given at the end of the second semester.

TABLE IV

MEAN COMPARISON OF MODERN ALGEBRA I TEST SCORES FOR TWENTY-FIVE MATCHED PAIRS (THIRTY-SIXTH WEEK TEST)

N	ΣD	$\overline{D}$	$\hat{s}_D$	Obtained t	Required t
25	+24	+.96	2.99	+1.57	2.06

It is evident, when observing Table IV, that the control group excelled the experimental group in mathematical achievement when measured by scores on the second semester modern algebra test. The positive difference between the mean scores of the two groups was larger for the second semester modern algebra test than it was for the first semester modern algebra test. The positive mean differences, on both modern algebra tests, resulted in t-scores favorable to the control group. Like the eighteenth week modern algebra t-score (+.585), the thirty-sixth week modern algebra t-score (+1.57) was not found to be statistically significant when a five per cent level of confidence was used.

Table V contains data pertaining to a mean comparison of achievement scores attained by the control and experimental groups. The scores resulted from the first semester traditional algebra test that was designed specifically for the traditional textbook used in the study.

TABLE V

MEAN COMPARISON OF TRADITIONAL ALGEBRA I TEST SCORES FOR TWENTY-FIVE MATCHED PAIRS (EIGHTEENTH WEEK TEST)

N	ΣD	$\overline{D}$	s_D	Obtained t	Required t
25	+69	+2.76	3.13	+4.32	2.06

As indicated by the positive difference in Table V, the control group had a larger mean score than the experimental group on the first semester traditional algebra test. The difference between the mean scores gave a t-score of +4.32. This t-score favored the control group and was statistically significant at the five per cent level of confidence.

Table VI is similar to Table V in that it presents a comparison of mean scores attained by the control and experimental groups on a traditional algebra test. This test, however, was designed as a second semester test for the traditional textbook used in the study.

TABLE VI

MEAN COMPARISON OF TRADITIONAL ALGEBRA I TEST SCORES FOR TWENTY-FIVE MATCHED PAIRS (THIRTY-SIXTH WEEK TEST)

N	ΣD	$\overline{D}$	s_D	Obtained t	Required t
25	+38	+1.52	2.69	+2.78	2.06

Table VI, like Table V, contains data favorable to the control group. The positive difference in scores between the control and experimental groups indicates the control group had a larger mean score. This larger mean score resulted in a difference between the means of +1.52 and a t-score of +2.78. Like the t-score (+4.32) for the first semester traditional test, this t-score (+2.78) favored the control group and was found to be statistically significant at the five per cent level of confidence.

The data contained in Table VII illustrates a comparison of the difference in mean scores which resulted from grade placement scores on the mathematics section of the California Achievement Test.

TABLE VII

MEAN COMPARISON OF GRADE PLACEMENT SCORES ON THE MATHEMATICS SECTION OF THE CALIFORNIA ACHIEVEMENT TEST: TWENTY-FIVE MATCHED PAIRS (THIRTY-SIXTH WEEK TEST)

N	ΣD	$\overline{D}$	s_D	Obtained t	Required t
25	+3.1	+.12	1.36	+.432	2.06

Table VII shows the mean of the sample of D-values to be +.12. This indicates the control group had a larger mean score on the mathematics section of the California Achievement Test administered during the thirty-sixth week of the study. The positive difference in mean scores resulted in a t-score of +.432. Although this t-score favored the control group, it was not statistically significant at the five per cent level of confidence.

Table VIII presents a mean comparison of total mathematical achievement attained by the control and experimental groups on the Elementary Algebra Test written by Lyle Eakins.

TABLE VIII

MEAN COMPARISON OF TOTAL MATHEMATICAL ACHIEVEMENT ATTAINED ON EAKIN'S ELEMENTARY ALGEBRA TEST TWENTY-FIVE MATCHED PAIRS (THIRTY-SIXTH WEEK TEST)

N	ΣD	$\overline{D}$	s_D	Obtained t	Required t
25	-4	-.16	6.84	-.115	2.06

It can be seen in Table VIII that the sum of differences between the scores in the control group and the scores in the experimental group was -4. The negative difference shows that the sum of scores was larger for the experimental group. As a result, the difference between the means of the two matched groups (-.16) favored the experimental group. However, the t-score of -.115 was not statistically significant at the five per cent level of confidence.

The data presented in Table IX shows a comparison of mean scores for the control and experimental groups on a test pertaining to knowledge of mathematical facts.

TABLE IX

MEAN COMPARISON OF SCORES ATTAINED ON PART 1
OF EAKIN'S ELEMENTARY ALGEBRA TEST:
KNOWLEDGE OF MATHEMATICAL FACTS
(THIRTY-SIXTH WEEK TEST)

N	ΣD	$\overline{D}$	$\hat{s}_D$	Obtained t	Required t
25	-14	-.56	3.14	-.87	2.06

As shown in Table IX, the sum of the differences was -14 and the difference between the means was -.56. Application of the t-test to this data resulted in a t-score of -.87. The negative t-score favored the experimental group, but it was not statistically significant at the five per cent level of confidence.

The data in Table X illustrates a comparison of mean scores attained by the control and experimental groups on a test involving analysis of problem situations.

TABLE X

MEAN COMPARISON OF SCORES ATTAINED ON PART 2
OF EAKIN'S ELEMENTARY ALGEBRA TEST:
ANALYSIS OF PROBLEM SITUATIONS
(THIRTY-SIXTH WEEK TEST)

N	ΣD	$\overline{D}$	$\hat{s}_D$	Obtained t	Required t
25	-12	-.48	1.98	-1.19	2.06

In Table X, the difference between the means (-.48) favored the experimental group and gave a t-score of -1.19. However, the difference was not statistically significant when a five per cent level of confidence was used.

Table XI presents a comparison of mean scores for the control and experimental groups on a test pertaining to skill in mathematical manipulations.

TABLE XI

MEAN COMPARISON OF SCORES ATTAINED ON PART 3 OF EAKIN'S ELEMENTARY ALGEBRA TEST: SKILL IN MATHEMATICAL MANIPULATIONS (THIRTY-SIXTH WEEK TEST)

N	ΣD	$\overline{D}$	δ_D	Obtained t	Required t
25	+22	+.88	5.30	+.81	2.06

As indicated in Table XI, the difference between means was +.88. This positive difference shows that the mean of the control group surpassed the mean of the experimental group in mathematical manipulations. Even though the t-score was +.81, it was not found to be statistically significant at the five per cent level of confidence.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

The purpose of this study was to compare the mathematical achievement of a control group taught first year algebra using the traditional method with that of an experimental group taught first year algebra using the modern method.

In developing this study, twenty-five matched pairs were randomly selected from a group of one hundred Alaskan Native high school students who desired to enroll in first year algebra during the 1967-68 school year. The students were closely matched on the basis of total mathematical achievement, algebraic ability, mental age, and intelligence.

The experiment was conducted in the classroom of the experimenter with teaching done in fifty minute periods, five days per week, for thirty-six weeks.

The findings of this study were based on the results of tests administered to the two groups during the eighteenth and thirty-sixth weeks. The *Lee Test of Algebraic Ability*, *Cumulative Test 14* written for Myron R. White's Elementary Algebra text, and *Cumulative Test 20* written for Houghton Mifflin's Modern Algebra text were used to determine mathematical achievement at the end of the first semester of the study. In addition, five tests were used to collect data on mathematical achievement at the end of the second semester.

These second semester tests were the Lee Test of Algebraic Ability, Form X: Advanced California Achievement Test, Form 4: Elementary Algebra Test copyrighted in 1954 and written by Lyle M. Eakins, Cumulative Test 22 written for White's Elementary Algebra, and a combination of Cumulative Tests 27 and 37 written for Houghton Mifflin's Modern Algebra Text.

After thirty-six weeks of study, tests were corrected and an analysis was made of the difference between the mean scores of the various tests. The t-test was used to determine statistical significance at the five per cent level of confidence.

Data collected from the various tests were used to justify the following summarization pertaining to mathematical achievement attained by Alaskan Native high school students at Mount Edgecumbe High School.

First Semester Mathematical Achievement. A comparison of means scores for first semester mathematical achievement indicated that the control group exceeded the experimental group on all three tests. However, the only difference in mean scores showing statistical significance was in the area of traditional algebra. A comparison of mean scores attained on the traditional algebra I test showed the mean score of the control group exceeded the mean score of the experimental group by 2.76. This difference resulted in a statistically significant t-score of +4.32.

Second Semester Mathematical Achievement. A comparison of mean scores for mathematical achievement at the end of thirty-six weeks revealed that the control group exceeded the experimental group on the modern algebra textbook test, the traditional algebra textbook test, the mathematics section of the California Achievement Test, and the mathematical manipulations section of Eakin's Elementary Algebra Test.

On the other hand, a comparison of mean scores for mathematical achievement showed the experimental group exceeded the control group on the Lee Test of Algebraic Ability, total mathematical achievement on Eakin's Elementary Algebra Test, the knowledge of mathematical facts section of Eakin's Elementary Algebra Test, and the analysis of problem situations section of Eakin's Elementary Algebra Test.

Although the control group exceeded the experimental group on four tests and vice versa, only one t-score was statistically significant at the five per cent level of confidence. Like the t-score (+4.32) for the first semester traditional algebra textbook test, the t-score (+2.78) for the second semester traditional algebra textbook test was found to be statistically significant at the five per cent level of confidence and favored the control group.

II. CONCLUSIONS

This study was based on the null hypothesis that no statistically significant difference would be found in mathematical achievement attained by Alaskan Native high school students taught first year algebra either by the traditional method or the modern method.

As a result of the data collected, the hypothesis, as stated for mathematical achievement, was retained. However, two of the eleven t-tests computed were statistically significant at the five per cent level of confidence.

It was found that the control group, when compared to the experimental group, achieved to a statistically significant degree on the first and second semester traditional textbook tests. This may be due in part to the fact that the two tests were designed specifically for the textbook used by the control group. This statistically significant difference between mean scores attained by the control and experimental groups may also be due to the lag in the presentation, by the Houghton Mifflin Modern Algebra I Textbook, of certain basic mathematical manipulations and computational processes. Some basic concepts are introduced later in modern algebra programs than they are in traditional algebra programs. This fact may be the reason the t-score for the second semester traditional textbook test was less than the t-score for the first semester traditional textbook test.

Even though the two t-scores for the traditional textbook tests showed statistically significant differences in mathematical achievement, the seven t-scores computed for various sections of three other traditional tests did not indicate statistically significant differences. Therefore, the experimenter concluded that Alaskan Native students in modern algebra I classes do about as well on traditional achievement tests as Alaskan Native students in traditional algebra I classes. Studies by K. E. Brown, T. L. Abell, The Minnesota National Laboratory, and Nicholas Kushta resulted in similar conclusions. These studies were cited on pages 12-14 of this thesis.

As a result of the scores attained on the two modern algebra tests, the experimenter arrived at a second conclusion. It was concluded that Alaskan Native students in traditional algebra I classes do as well on modern algebra tests as Alaskan Native students in modern algebra I classes. This conclusion was not confirmed by previous research because the experimenter was unable to locate studies that used modern algebra tests to determine statistical significance.

The results of the post-tests led the experimenter to a third conclusion that Alaskan Native students taught by the concept or modern method do not develop a significantly greater understanding of the nature of mathematics as a whole than Alaskan Native students taught by the traditional method. This conclusion was in opposition to the second conclusion arrived at by Nicholas Kushta in a study cited on pages 13-14.

III. RECOMMENDATIONS

As a result of the evidence and conclusions presented in this study, the following recommendations appear to be justified:

1. Additional research should be conducted in the area of modern mathematics versus traditional mathematics. The research should continue over a longer period of time and more areas of modern mathematics should be included.

2. Similar studies should involve larger samples so as to allow more generalizations and conclusions.

3. More comprehensive tests, based on the desired goals of modern mathematics programs, need to be developed so that they may be used as a measure of achievement in future studies.

4. Analysis of standard achievement tests shows that many of the goals of the traditional and modern curricula are not measured by existing tests. A basis for comparison of mathematics curricula is needed. Goals which any mathematics curriculum should aim at need to be defined and tests constructed, independent of any particular curriculum, to measure the extent to which any given program attains these objectives.

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APPENDIX

TABLE XII

DATA USED TO EQUATE THE CONTROL (C) AND EXPERIMENTAL (E) GROUPS
(August 1967-September 1967)

Matched Pair	Chronological Age		Mental Age		Lee Test of Algebraic Ability		Calif. Achievement Test-Math		Deviation I Q	
	C	E	C	E	C	E	C	E	C	E
1	16-09	17-04	14-06	13-11	23	23	10.0	9.8	93	88
2	16-10	16-09	13-00	13-07	24	24	10.0	9.5	83	87
3	15-05	15-08	13-04	13-07	26	24	8.8	8.9	90	90
4	15-09	15-06	14-03	14-06	29	31	8.5	8.5	94	97
5	16-06	16-07	17-02	17-00	29	30	8.5	8.5	110	109
6	17-07	17-08	14-07	15-06	30	30	9.1	8.9	92	98
7	17-02	17-04	15-01	14-11	32	31	9.7	9.9	96	95
8	17-03	17-10	15-08	15-00	32	32	8.7	9.0	95	95
9	16-07	16-04	16-03	16-11	33	34	9.2	9.2	104	109
10	17-06	16-10	16-10	16-10	33	33	9.5	10.0	107	108
11	16-03	16-00	17-10	17-08	33	34	11.5	11.4	115	114
12	14-09	15-00	14-08	15-00	33	34	9.6	9.4	102	103
13	17-02	16-10	14-05	14-07	35	35	8.5	8.3	92	93
14	15-02	14-07	15-07	15-02	35	36	11.1	11.3	106	106
15	17-07	17-00	14-07	15-01	37	37	10.5	10.4	92	96
16	15-11	16-07	16-00	16-01	37	36	9.6	9.5	104	103
17	16-01	16-08	14-06	14-03	37	36	11.8	11.7	94	91
18	17-04	17-01	15-10	15-04	37	37	9.1	9.2	101	98
19	14-00	14-04	17-11	17-10	42	41	8.7	9.0	127	124
20	17-07	17-10	16-04	16-01	42	41	11.0	11.5	104	102
21	14-06	14-04	17-03	17-00	43	45	10.5	10.5	120	119
22	14-08	14-05	17-00	17-00	48	47	11.2	11.1	118	119
23	13-06	15-01	16-06	16-06	48	48	11.9	11.7	120	112
24	17-08	17-06	15-00	14-08	48	47	11.0	11.0	95	93
25	15-08	15-10	17-00	17-03	54	55	12.8	13.0	112	112
Mean	16-02	16-03	15-08	15-08	36	36	10.0	10.0	103	102
Median	16-06	16-07	15-08	15-04	35	35	9.7	9.8	102	102

TABLE XIII

LEE TEST OF ALGEBRAIC ABILITY RAW SCORE CHANGES AFTER EIGHTEEN WEEKS OF INSTRUCTION AND DIFFERENCES BETWEEN SCORE CHANGES (JANUARY 1968)

Matched Pair	Control Group	Experimental Group	Difference (X_C-X_E)	Difference Squared
1	+11	+ 5	+ 6	36
2	+11	+ 9	+ 2	4
3	+14	+ 4	+10	100
4	+10	+14	- 4	16
5	+14	+ 9	+ 5	25
6	+ 5	+ 5	0	0
7	+14	+ 7	+ 7	49
8	+ 6	+10	- 4	16
9	+17	0	+17	289
10	+ 8	+12	- 4	16
11	+13	+12	+ 1	1
12	+10	+11	- 1	1
13	+ 7	+ 5	+ 2	4
14	+14	+17	- 3	9
15	+ 7	+ 3	+ 4	16
16	+ 6	+ 8	- 2	4
17	+15	+ 3	+12	144
18	+ 2	+16	-14	196
19	+ 9	+17	- 8	64
20	+ 9	+ 8	+ 1	1
21	+11	+15	- 4	16
22	+ 3	+14	-11	121
23	+ 9	0	+ 9	81
24	0	0	0	0
25	0	0	0	0
Totals	+225	+204	+21	1209

TABLE XIV

LEE TEST OF ALGEBRAIC ABILITY RAW SCORE CHANGES
AFTER THIRTY-SIX WEEKS OF INSTRUCTION AND
DIFFERENCES BETWEEN SCORE CHANGES
(MAY 1968)

Matched Pair	Control Group	Experimental Group	Difference ($X_C - X_E$)	Difference Squared
1	+11	+11	0	0
2	+18	+ 9	+ 9	81
3	+15	+10	+ 5	25
4	+10	+17	- 7	49
5	+14	+14	0	0
6	+ 5	+ 5	0	0
7	+14	+ 7	+ 7	49
8	+15	+14	+ 1	1
9	+17	+13	+ 4	16
10	+10	+12	- 2	4
11	+15	+15	0	0
12	+10	+11	- 1	1
13	+11	+ 9	+ 2	4
14	+14	+25	-11	121
15	+ 7	+ 5	+ 2	4
16	+10	+ 8	+ 2	4
17	+19	+ 9	+10	100
18	+ 4	+16	-12	144
19	+12	+17	- 5	25
20	+ 9	+ 8	+ 1	1
21	+14	+15	- 1	1
22	+ 4	+14	-10	100
23	+ 9	0	+ 9	81
24	0	0	0	0
25	0	+ 6	- 6	36
Totals	267	270	- 3	847

TABLE XV

RAW SCORES FOR TRADITIONAL TEXTBOOK ALGEBRA TEST AND DIFFERENCES BETWEEN THE RAW SCORES (JANUARY 1968)

Matched Pair	Control Group	Experimental Group	Difference (X_C-X_E)	Difference Squared
1	13	11	+ 2	4
2	11	9	+ 2	4
3	13	9	+ 4	16
4	17	11	+ 6	36
5	9	12	- 3	9
6	16	9	+ 7	49
7	15	9	+ 6	36
8	11	12	- 1	1
9	13	12	+ 1	1
10	10	11	- 1	1
11	15	13	+ 2	4
12	13	11	+ 2	4
13	13	11	+ 2	4
14	14	12	+ 2	4
15	16	11	+ 5	25
16	14	13	+ 1	1
17	15	10	+ 5	25
18	17	11	+ 6	36
19	9	14	- 5	25
20	17	11	+ 6	36
21	17	9	+ 8	64
22	15	11	+ 4	16
23	19	14	+ 5	25
24	13	10	+ 3	9
25	11	11	0	0
Totals	346	277	+69	435

TABLE XVI

RAW SCORES FOR TRADITIONAL TEXTBOOK ALGEBRA TEST
AND DIFFERENCES BETWEEN THE RAW SCORES
(MAY 1968)

Matched Pair	Control Group	Experimental Group	Difference (X_C-X_E)	Difference Squared
1	14	11	+ 3	9
2	13	15	- 2	4
3	13	12	+ 1	1
4	19	14	+ 5	25
5	12	13	- 1	1
6	15	11	+ 4	16
7	15	14	+ 1	1
8	13	13	0	0
9	13	12	+ 1	1
10	10	13	- 3	9
11	16	16	0	0
12	16	13	+ 3	9
13	16	14	+ 2	4
14	20	17	+ 3	9
15	20	14	+ 6	36
16	17	12	+ 5	25
17	14	17	- 3	9
18	15	16	- 1	1
19	16	16	0	0
20	19	17	+ 2	4
21	23	16	+ 7	49
22	17	15	+ 2	4
23	17	13	+ 4	16
24	13	15	- 2	4
25	18	17	+ 1	1
Totals	394	356	+38	238

TABLE XVII

RAW SCORES FOR MODERN ALGEBRA TEXTBOOK TEST
AND DIFFERENCES BETWEEN RAW SCORES
(JANUARY 1968)

Matched Pair	Control Group	Experimental Group	Difference ($X_C - X_E$)	Difference Squared
1	21	21	0	0
2	24	23	+ 1	1
3	23	22	+ 1	1
4	26	24	+ 2	4
5	21	25	- 4	16
6	21	24	- 3	9
7	25	25	0	0
8	21	21	0	0
9	22	20	+ 2	4
10	24	22	+ 2	4
11	27	22	+ 5	25
12	22	25	- 3	9
13	25	25	0	0
14	23	22	+ 1	1
15	24	23	+ 1	1
16	23	22	+ 1	1
17	23	21	+ 2	4
18	24	25	- 1	1
19	21	22	- 1	1
20	27	27	0	0
21	25	25	0	0
22	26	23	+ 3	9
23	23	26	- 3	9
24	23	22	+ 1	1
25	24	25	- 1	1
Totals	588	582	+ 6	102

TABLE XVIII

RAW SCORES FOR MODERN ALGEBRA TEXTBOOK TEST
AND DIFFERENCES BETWEEN RAW SCORES
(MAY 1968)

Matched Pair	Control Group	Experimental Group	Difference (X_C-X_E)	Difference Squared
1	21	19	+ 2	4
2	17	20	- 3	9
3	19	19	0	0
4	23	22	+ 1	1
5	21	20	+ 1	1
6	20	19	+ 1	1
7	21	22	- 1	1
8	23	24	- 1	1
9	24	20	+ 4	16
10	18	20	- 2	4
11	28	19	+ 9	81
12	24	18	+ 6	36
13	22	17	+ 5	25
14	23	22	+ 1	1
15	21	21	0	0
16	23	21	+ 2	4
17	20	21	- 1	1
18	21	24	- 3	9
19	18	22	- 4	16
20	22	23	- 1	1
21	27	23	+ 4	16
22	20	21	- 1	1
23	23	19	+ 4	16
24	20	19	+ 1	1
25	24	24	0	0
Totals	543	519	+24	246

TABLE XIX

GRADE PLACEMENT CHANGES INDICATED BY SCORES ON THE CALIFORNIA ACHIEVEMENT TEST AND DIFFERENCES BETWEEN THE CHANGES (MAY 1968)

Matched Pair	Control Group	Experimental Group	Difference ($X_C - X_E$)	Difference Squared
1	0.1	2.2	-2.1	4.41
2	2.2	1.2	+0.8	0.64
3	2.1	1.8	+0.3	0.09
4	2.9	4.4	-1.5	2.25
5	3.4	3.2	+0.2	0.04
6	1.0	0.0	+1.0	1.00
7	0.9	1.2	-0.3	0.09
8	3.3	1.1	+2.2	4.84
9	2.3	1.7	+0.6	0.36
10	0.7	0.5	+0.2	0.04
11	2.0	2.0	0.0	0.00
12	2.3	2.9	-0.6	0.36
13	3.7	2.8	+0.9	0.81
14	0.0	2.6	-2.6	6.76
15	0.9	1.3	-0.4	0.16
16	0.1	3.6	-3.5	12.25
17	1.4	0.2	+1.2	1.44
18	3.0	0.3	+2.7	7.29
19	3.0	2.3	+0.7	0.49
20	3.5	3.6	-0.1	0.01
21	4.2	3.2	+1.0	1.00
22	2.4	0.9	+1.5	2.25
23	2.3	1.9	+0.4	0.16
24	1.3	1.0	+0.3	0.09
25	0.2	0.0	+0.2	0.04
Totals	49.0	45.9	+3.1	46.87

TABLE XX

RAW SCORES FOR EAKIN'S ELEMENTARY ALGEBRA TEST
AND DIFFERENCES BETWEEN THE RAW SCORES
(MAY 1968)

Matched Pair	Control Group	Experimental Group	Difference (X_C-X_E)	Difference Squared
1	77	80	- 3	9
2	76	81	- 5	25
3	77	73	+ 4	16
4	83	79	+ 4	16
5	84	88	- 4	16
6	79	72	+ 7	49
7	67	70	- 3	9
8	78	80	- 2	4
9	91	73	+18	324
10	68	75	- 7	49
11	97	82	+15	225
12	79	74	+ 5	25
13	77	85	- 8	64
14	83	85	- 2	4
15	78	81	- 3	9
16	81	82	- 1	1
17	74	88	-14	196
18	83	83	0	0
19	76	86	-10	100
20	88	88	0	0
21	93	94	- 1	1
22	84	79	+ 5	25
23	78	77	+ 1	1
24	73	72	+ 1	1
25	81	82	- 1	1
Totals	2005	2009	- 4	1170

TABLE XXI

RAW SCORES FOR KNOWLEDGE OF MATHEMATICAL FACTS SECTION OF EAKIN'S ALGEBRA TEST AND DIFFERENCES BETWEEN SCORES (MAY 1968)

Matched Pair	Control Group	Experimental Group	Difference ($X_C - X_E$)	Difference Squared
1	34	38	- 4	16
2	31	37	- 6	36
3	35	38	- 3	9
4	35	34	+ 1	1
5	36	40	- 4	16
6	39	38	+ 1	1
7	32	33	- 1	1
8	33	36	- 3	9
9	40	33	+ 7	49
10	30	36	- 6	36
11	39	36	+ 3	9
12	36	35	+ 1	1
13	31	34	- 3	9
14	34	36	- 2	4
15	32	30	+ 2	4
16	33	35	- 2	4
17	34	37	- 3	9
18	39	33	+ 6	36
19	39	38	+ 1	1
20	33	33	0	0
21	39	40	- 1	1
22	36	36	0	0
23	37	36	+ 1	1
24	30	29	+ 1	1
25	38	38	0	0
Totals	875	889	-14	254

TABLE XXII

RAW SCORES FOR ANALYSIS OF PROBLEM SITUATIONS SECTION OF EAKIN'S ALGEBRA TEST AND DIFFERENCES BETWEEN RAW SCORES (MAY 1968)

Matched Pair	Control Group	Experimental Group	Difference (X_C-X_E)	Difference Squared
1	24	25	- 1	1
2	27	26	+ 1	1
3	24	27	- 3	9
4	22	22	0	0
5	28	24	+ 4	16
6	25	24	+ 1	1
7	25	26	- 1	1
8	25	28	- 3	9
9	29	29	0	0
10	23	28	- 5	25
11	28	26	+ 2	4
12	23	24	- 1	1
13	25	27	- 2	4
14	25	28	- 3	9
15	29	28	+ 1	1
16	28	26	+ 2	4
17	27	27	0	0
18	27	27	0	0
19	23	26	- 3	9
20	29	30	- 1	1
21	28	29	- 1	1
22	28	26	+ 2	4
23	25	26	- 1	1
24	26	25	+ 1	1
25	23	24	- 1	1
Totals	646	658	-12	104

TABLE XXIII

RAW SCORES FOR SKILL IN MATHEMATICAL MANIPULATIONS SECTION OF EAKIN'S ALGEBRA TEST AND DIFFERENCES BETWEEN SCORES (MAY 1968)

Matched Pair	Control Group	Experimental Group	Difference $(X_C - X_E)$	Difference Squared
1	19	17	+ 2	4
2	18	18	0	0
3	18	8	+10	100
4	26	23	+ 3	9
5	20	24	- 4	16
6	15	10	+ 5	25
7	10	11	- 1	1
8	20	16	+ 4	16
9	22	11	+11	121
10	15	11	+ 4	16
11	30	20	+10	100
12	20	15	+ 5	25
13	21	24	- 3	9
14	24	21	+ 3	9
15	17	23	- 6	36
16	20	21	- 1	1
17	13	24	-11	121
18	17	23	- 6	36
19	14	22	- 8	64
20	26	25	+ 1	1
21	26	25	+ 1	1
22	20	17	+ 3	9
23	16	15	+ 1	1
24	17	18	- 1	1
25	20	20	0	0
Totals	484	462	+22	722

TABLE XXIV

MEAN DIFFERENCES, STANDARD DEVIATIONS OF THE SAMPLES OF D-VALUES AND t-SCORES USED TO DETERMINE STATISTICALLY SIGNIFICANT DIFFERENCES AT THE FIVE PER CENT LEVEL OF CONFIDENCE

Test	Eighteenth week test			Thirty-sixth week test		
	$\overline{D}$	σ_D	t-score	$\overline{D}$	σ_D	t-score
Lee Test of Algebraic Ability	+0.84	6.90	+0.596	-0.12	5.82	-0.101
Traditional Textbook Test	+2.76	3.13	+4.320	+1.52	2.69	+2.780
Modern Textbook Test	+0.24	2.01	+0.585	+0.96	2.99	+1.570
Calif. Achievement Test-Math				+0.12	1.36	+0.432
Eakin's Elementary Algebra Test (Total Test)				-0.16	6.84	-0.115
Eakin's Elementary Algebra Test (Mathematical Facts)				-0.56	3.14	-0.870
Eakin's Elementary Algebra Test (Problem Situations)				-0.48	1.98	-1.190
Eakin's Elementary Algebra Test (Mathematical Manipulations)				+0.88	5.30	+0.810

$\overline{D}$ = The difference between the means $(\overline{X}_C - \overline{X}_E)$

σ_D = The standard deviation of the sample of D-values