A COMPARATIVE STUDY OF THE TEACHING OF FIRST YEAR ALGEBRA

By

ALLEN MAYNARD ROBSON

Bachelor of Science
Oklahoma Baptist University
Shawnee, Oklahoma
1937

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1949

Submitted to the Faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF EDUCATION
August, 1965

A COMPARATIVE STUDY OF THE TEACHING OF

FIRST YEAR ALGEBRA

Thesis Approved:

J. Rowland Freeman
Thesis Adviser

Helen M. Jones

H E Sorenson

Guy R. Donnell

J H Boggs
Dean of the Graduate School

PREFACE

This study was to determine if there were significant gains in student achievement in Algebra I when different teaching methods were used. The methods involved the conventional method of the teaching of algebra and the programmed method of instruction. The study was limited to one junior high school and evaluated student achievement in Algebra I for one semester.

A survey of literature indicated that several studies had been made concerning achievement when a program had been used. The results of the survey indicated that students achieved success in the learning of subject matter when programmed materials were used. The survey failed to reveal studies that contrasted achievement gains when different approaches to learning were followed. The author was interested in determining the influence on achievement when students were exposed to programmed instruction versus conventional methods of teaching.

Indebtedness is acknowledged to Dr. J. Paschal Twyman, who served as chairman of my advisory committee, for encouraging my interest in the problem and for his guidance throughout the study; to Dr. Stanley Trail and to Dr. James Tarver for their suggestions and guidance in the statistical treatment of the data; to Dr. Guy Donnell, Mrs. Helen Jones and Dr. Helmer Sorenson for their kind and helpful advice. I am especially indebted to Dr. J. Win Payne and Dr. Sorenson who offered encouragement to complete the doctoral program.

The efforts and cooperation of Mr. Harold Lewis, head of the mathematics department at West Junior High School, were greatly appreciated. The cooperation of this dedicated teacher made the study possible.

To my wife and son, I say thanks for donating that part of your time that made possible the completion of my course of study.

To the many persons who helped make the completion of this study possible the writer extends appreciation.

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

CHAPTER I

THE PROBLEM

Introduction

Automation and the exploration of space have opened many new fields for mathematical emphasis. This has resulted in mathematics being one of the fastest growing and most rapidly changing of all the sciences.

Educational change comes slowly, and if change is to be significant, it is necessary to have adequate planning. The content in mathematics text books and the methods of teaching mathematics will have to change if American youth are to be prepared to compete successfully in the space age. If educators agree with the thesis that the acquired knowledge of man prior to 1900 doubled by 1950, doubled again by 1960, and will double once more by 1967, they will not be as reluctant to change content and methods as they have in the past.

Many articles have been written calling for improved methods of instruction at all educational levels. If new teaching methods have been developed that will enable the teacher to accomplish better teaching, it is a challenge to all schools to use them. Certainly if new methods can bring about greater mathematical achievement and a better understanding of mathematical concepts on the part of students, these methods should be used.

The Encyclopedia Britannica Program for first year algebra includes the conventional course offerings. The algebra curriculum has developed through tradition an accepted sequence of topics. Temac, the trade name for the program developed by Encyclopedia Britannica, encompasses what is commonly referred to as traditional algebra. New concepts and terminology that are used in the School Mathematics Study Group materials are not included in Temac.

Programmed materials support the Effect Theory of learning. The Effect Theory maintains that learning requires stimulus-response contiguity (stimulus and a response to occur closely together in time) and reward in the form of satisfaction or drive reduction. Psychologists recognize the S-R Formula for learning is, at best, incomplete. There is a recognition that a great deal goes on between Stimulus-Response, and that a response must be reinforced if learning is to take place.

Research indicates that practice alone does not produce learning, but only fatigue or extinction. To insure the occurrence of learning, it is necessary to employ the operation of reinforcement. A learned response when reinforced will more likely occur the second time. The failure to reinforce a response decreases the probability of occurrence of the response.

Psychologists point out that learning takes place when a response receives a satisfactory reinforcement. A pigeon pecking a key to get a light to come on or a rat operating a device to obtain food are examples in their studies indicating that learning takes place when a response receives a satisfactory reinforcement.

Research indicates that more effective learning takes place when responses are immediatesly reinforced. When the reward or reinforcer is immediate, learning takes place at a faster pace. Reactions followed by immediate reinforcements are better learned than those more remote from reinforcement. Also, learning increases with increased amount of reinforcement. Watson (56) states that behaviors which are reinforced are more likely to recur. The reinforcement to be most effective in learning must follow immediately the desired behavior. Much of the effectiveness of programmed learning lies in that fact that information about success is immediately fed back for each response.

Programmed materials for Algebra I use the theory of Stimulus-Response-Reinforcement. The problem is the stimulus. The answer given by the student is the response. The student can obtain immediate satisfaction by checking his response with the answer provided for him. The answer and sequential problems are used to reinforce each response given by the student.

Statement of the Problem

The public was calling for change in educational practices. Administrators were faced with the problem of introducting new mathematical content as well as new methods of presentation. Most administrators and school systems are reluctant to change content or teaching methods until there is statistical evidence establishing superiority of the new material or method. All suggested changes raise questions as to what can be expected from the change. Who will gain, and who will lose if this change is made?

The problem of this study was to determine if there are significant differences in student achievement in first year algebra when different procedures are used.

Purpose of the Study

Temac has been in limited operation for four years. During this period of time there has been a number of studies made showing that students achieve when programmed teaching is used. However, we also know that achievement gains are made when conventional teaching methods are used. There is a lack of research comparing student achievement when the programmed method is compared to conventional methods of instruction.

The purpose of this study was to compare student achievement in first year algebra when divergent teaching methods are used. Programmed materials have not been used to any great extent in the Ponca City School System or in Ponca City West Junior High School. The teachers were interested in developing an understanding of programmed materials and how they can be most effectively used in the curriculum. There was also a desire to determine if there were significant gains in student achievement when the programmed approach was used in contrast to the conventional approach in the teaching of algebra at the junior high school level in Ponca City, Oklahoma.

Limitations of the Study

The study was limited to a small population. It would have been desirable to have a larger population and larger samples, but from a practical and financial point of view a larger sample could not be used. The study was confined to one school; it was also limited to student achievement in the first course in algebra for one semester. Inferences are limited to the population that was sampled.

Scope of the Study

The study was concerned with student achievement in the first course in algebra at West Junior High School, Ponca City, Oklahoma. The population from which the samples were drawn included ninth grade students enrolled in conventional algebra. The students had completed the Henmon-Nelson Test of Mental Ability, the Orleans Prognosis Test for Algebraic Achievement, and had made satisfactory progress in eighth grade mathematics.

The socio-economic background of all students included in the study was that found in a city of 30,000 population, located in North Central Oklahoma. The city is the business and cultural center for a prosperous oil and agriculturally oriented community. Most of the parents of students in the study had average or above average incomes, and most of the professions and job classifications were represented.

The Ponca City School System is organized on the 6-3-3 plan. In the elementary grades a semi-platoon system of organization is used. The junior high school program is departmentalized. A great majority of the students in this study are products of the system.

Definition of Terms As Used in the Study

Some terms in the study may require clarification. The less familiar of these terms are the following:

First Year Algebra. This is the conventional algebra course that is usually offered to ninth grade students. In some junior high schools eighth grade students will take this course.

Achievement in Algebra. Expressed by a standard score obtained by administering the AM and BM Forms of the Seattle Algebra Test.

Standard Score. Gives a comparable base in order to compare several sets of scores. The standard score is found by obtaining the deviation of a score from the mean and dividing by the standard deviation.

Conventional Teaching Method. That method is usually found in the typical classroom with the teacher using the lecture and demonstration method. The students responding to questions and are studying the same material at the same time.

Programmed Materials. Are materials that attempt to combine the knowledge of the subject matter specialist with that of the experimental psychologist. The content is broken down into small sequential segments or frames. The frames are carefully organized to give students a step-by-step comprehension, along with sufficient review, of the subject matter covered.

Temac. Name given to program used in this study. The name refers to the program that was developed by Encyclopedia Britannica for the first course in algebra.

Population. All ninth grade students at Ponca City West Junior High School enrolled in first year algebra.

Group A. The group that makes use of programmed materials.

Group B. A group that is taught by conventional methods.

Group C. A group that is taught by conventional methods.

Statistically Significant. The use of a five percent level of confidence in determining the probability of a certain event occurring by chance more often than five in one hundred.

The Analysis of Covariance. Statistical adjustment for initial differences in variables which provides a method of adjusting student scores whose pre-treatment achievement or ability scores were not equal.

Orleans Prognosis Test. A test given to predict success in algebra. The split-half reliability of this test is .92.

Seattle Algebra Test. The test has been designed to measure the achievement of students in the important objectives of the first half year of a high school course in beginning algebra. It is essentially a power test and has an alternate form reliability of .87.

Attitude Scale. The instrument measures attitudes towards mathematics and consists of 45 weighted items. The reliability of the attitude scale was checked at Lendblom High School in Chicago and the Pearson Correlation Coefficient obtained was .98.

t. Test. Test used to compare two means. t is the ratio of a deviation from the mean, in a distribution of sample statistics, to the standard error of that distribution. The test allows us to contrast the significance of the difference of mean scores. The test can only deal with 2 mean scores at one time and one independent variable. t test deals with parametric measurement of interval size and normal distribution.

Henmon-Nelson Test of Mental Ability. Form A for grades 6-9 was used in this study. The test consists of 90 items and is published by Houghton Mifflin Co. The reliability coefficient for Form A with ninth grade students is .94.

Chi Square. χ^2 is a method of comparing observed or obtained results with those to be expected theoretically on some hypothesis.

Hypotheses to be Tested

In the course of this study the following hypotheses were tested:

1. There will be a difference in the achievement levels of groups A, B, and C at the end of the first semester. $P < .05$

2. There will be a difference in favorable attitudes toward mathematics, as exemplified by the students in each group, at the end of the instructional period. $P < .05$

3. There will be a significant difference in the ability to understand algebraic vocabulary at the end of the first semester. $P < .05$

4. There will be a significant difference in the ability to use fundamental processes. $P < .05$

5. There will be a significant difference in the ability to solve equations. $P < .05$

6. There will be a significant difference in the ability to represent relationships algebraically and to set up equations for given problems. $P < .05$

7. There will be significant difference in the choice of teaching methods at the end of the instructional period. $P < .05$

SUMMARY

The literature informs us that mathematics is the fastest growing and the most rapidly changing segment of all the sciences. The scope and sequence of mathematics courses are being changed in the schools of this nation. Along with the change in content it is imperative that we study changes in presentation of subject matter and changes in teaching methods. If allowances for individual differences are to be made, changes in conventional teaching methods must come. Programmed material may help us to make this change. If programs are to be accepted by the professional teacher, there has to be evidence available that the new method is superior to or equal to conventional ones.

This study was to determine the achievement of each of three groups of students and to determine if there was a significant difference in achievement. In addition to total achievement in Algebra I a study was made of achievement in four areas of Algebra I: understanding of algebraic vocabulary; use of fundamental processes; solution of equations; and the representation of relationships algebraically. A study was made in the change of attitudes of students toward mathematics. A test for significance of choice of teaching methods at the end of the instructional period was made.

CHAPTER II

Review of the Literature

The Encyclopedia Britannica Programmed Materials for the teaching of first year algebra were developed in a workshop at Roanoke, Virginia. The workshop was under the direction of Loetta W. Horton and consisted of thirty-six mathematics teachers. At the present time the program developed in this workshop is used by more than four hundred school systems, colleges, and universities.

At Roanoke in the fall of 1960 an experiment began in the use of the program. Some five hundred and fifty students completed the courses in Algebra I and II, trigonometry and calculus. The students were randomly assigned and had varying degrees of ability. The eleven teachers assigned to the program had no previous training or orientation for the task.

The teachers were reported to have been well satisfied with the results obtained. The tests were made by the teachers, and improved student achievement was observed. The mathematics faculty experienced much professional growth. The Roanoke Teachers agree that the best and most effective way of using programmed material is still the subject of debate.

Cronback (11) reports that research concerning the effectiveness of programmed materials is fragmentary. Research indicates that when the teacher is favorable to the use of the program that pupil progress is at least equal to conventional classes and sometimes superior. When the teacher is unfavorable to programmed instruction, the pupil performance is inferior. Studies suggest that programs teach facts as well as conventional procedures do. Follow-up tests often indicate startling deficiencies in mathematics when pupils have been taught by programmed instruction. Evidence now available gives little support to the view that instruction calling for one active response after another will teach better than conventional methods.

It is fairly evident that a pupil learns something from well programmed material. The aims should be the improvement of learning for boys and girls and focusing of attention on the individual learner. The program should not be looked upon as a way of cutting the staff.

Lunsdaine (34) states that the public should be informed concerning the potential promise and practical limitations of programmed materials. There is need for government research in the field to improve techniques and to provide firm foundation for subsequent practical developments. Standardized technique for assessing the program should be developed.

It is unfortunate that this new technique in education first became popularized under the head of "Teaching Machines." This is unfortunate because a machine cannot teach, and the image of a mechanical device replacing the teacher is envisioned. Nasca (41) suggests a more appropriate name for this new methodology is "Programmed Learning."

McGarvey (36) found that pupils enrolled in summer school in the Algebra Improvement Course using Temac showed considerable improvement in the mastery of algebra. The student reaction to programmed instruction was favorable. The teacher found that he did not have an opportunity to lecture to the entire group, but that he had more time for individual students. The study reports that the teacher had more time to enrich the learning of faster learners and that remedial work with slower students was more easily accomplished.

Clark (10) states that no single discovery made in the process of educating children and adults has the potential of programmed learning. Careful study should be made of a program before it is selected for use. A well constructed program will allow a pupil to learn mathematics and to learn it with interest and understanding. Good programs will enable us to raise the mathematical competence of many who have been doomed to failure.

In education we are confronted with many demands for curriculum change. The teacher is challenged to change his mode of teaching. Programmed instruction offers him a way to change. The process of programming amounts to taking a body of material to be learned and presenting it in an orderly sequence of units. Each unit is organized in small steps which are formed as questions. Programmed materials may be presented in various ways. There are available teaching machines and programmed textbooks. The presentation is not as important as the content of the program.

Moore (39) observes that if programmed materials are to continue to be useful they must provide not only for individual differences in ability but also for individual differences in motivation to achieve. The writer urges that students be grouped by level of ability and regrouped by type of motivation. The probability of success influences pupils' attitudes toward program learning. Those who are strongly disposed to "fear of failure" prefer tasks extremely easy or extremely difficult and avoid tasks that offer only a fifty percent probability success because such tasks involve the ego. A pupil who fears failure will show more interest in the program when the probability of success becomes greater than fifty percent. The task becomes more pleasant for him. The pupil who has "high hopes of success" loses interest with continued success or continued failure. His interest will increase as the probability of success approaches the fifty percent level. The pupil when free to choose and who has a "high hope of success" will look for new and more difficult tasks as he masters old ones. Motivation and achievement are strongly related. The experiments suggest that some pupils, when using programmed instruction or when learning through the conventional methods of instruction, require a challenging, difficult approach to the learning of a concept; others with the same ability require an easy, nonthreatening method for learning the same concept. The research made by Moore indicates that for all types of students to be motivated it is necessary for programmed materials to have different levels of difficulty.

In 1963 it was estimated that about one million school children would be exposed to the technique of teaching called "programmed instruction." In five years the use of the technique has spread from a handful of experimental classrooms to more than 5,000 schools across the nation. It is estimated that the number could easily triple by 1965. For many, programmed instruction has become a symbol of progress. However, many educators who at first embraced the new technique are now backing away and taking a second look. Some think that programmed teaching has been over estimated, and a few educators think that the use of programmed instruction is dangerous.

Many studies indicate that students learn when a program is used. Dr. B. F. Skinner, Harvard's famous behavorial psychologist, claims that the use of a program is the best way to learn. About 1953, while experimenting with pigeons, Skinner discovered that the birds could be taught to accomplish many astonishing feats provided that each step of behavior was rewarded with a grain of corn. Many psychologists call the process of rewarding "reinforcement." Reinforcement is important to the theories about programmed instruction. In 1954 Skinner published an article in which he argued that people could be taught in the same way he taught his pigeons. This article signaled the birth of programmed instruction. In a program for people the reinforcement factor is encouragement. The student is rewarded at each step by being told that his answer is correct. The programmer arranges his material in such a way as to invite correct responses.

Many educators say, "People aren't pigeons," and are disturbed by the rigid application of laboratory theory to the classroom situation. They are alarmed when the programmer attempts to change the art of teaching to an exact science. The teachers warn that the new technique contains a number of serious defects. The defects most commonly mentioned are these: most programmed instruction discourages critical thinking; a program fosters rote learning and the memorization of facts; in spite of reinforcement most programmed instruction is both mechanical and monotonous, and it is an uninspiring way to learn. The literature points out that a program will help a student memorize facts, but the program has not been made that will teach the student to enjoy the facts. Educators are placing renewed emphasis on teaching students how to think. Many educators claim that the program approach to teaching is discouraging children to think.

There are both good and bad programs being produced and sold. There has been too much haste on the part of publishers to produce programs. The publishers have supported little research in the field of programmed materials. Some programs have been developed and placed on the market during a five weeks' period. Research indicates that it may require two years to produce effective programmed materials. The inferior programs have found their way into homes and schools. So widespread has home use of the new technique become that the Center for Programmed Instruction, a nonprofit organization, has found it necessary to issue a "Parents' Guide" that warns the parents concerning the bad programs.

Some communities have looked to programmed instruction as a way to replace teachers and thus lower the tax rate. This has not taken place as the program will not replace the teacher. In most cases the program is an aid to the teacher and not a threat to him. The issue is not whether a program can replace a teacher, but how teachers can best use the new technique.

The selection and use of programmed learning materials should receive detailed attention from the school administrator and the classroom teacher. Before using this new educational tool, a school needs to answer questions such as the following:

> "What is the basic nature of programmed material?
> Will this basic nature be respected?
> What function of the teaching tasks is to be expected of the programmed learning materials?

Who will be the key persons in implementing the use?
How, when, and where will materials be used?"[1]

All programming is based on some common assumptions:

"If a student does not learn, it is the instruction that is failing.

The individual learner is a class of one and is entitled to instruction fitted to him and his uniqueness.

Whatever is to be learned is to be analyzed for basic orderliness and organized into a behavioral catalog of the component skills and concepts.

Learning is facilitated by a continuous knowledge of progress with a high degree of success, by orderly progress, and by being presented in a series of steps which have been pretested on like-minded students with similar backgrounds.

As a corollary, if a learner is continuously to be guided by himself or by a teacher in his learning, there should be some overt behavior that makes it evident that the learning is moving in the desired direction."[2]

Many of these principles may be at variance with common school practices as grading, promotion, and scheduling. Once a school has decided to use programmed materials and that the goals of the school and the goals of programmed learning are compatible, the school must decide what functions it may expect the program material to perform. Three possible approaches are these: Will the program be used as a substitute for the teacher? Will it be used to supplement the efforts of the teacher or to increase the productivity of instruction?

Usually the program is not expected to do the total task of teaching. Most educators rely on program materials for supplementary

---

[1]Phil C. Large, "Selection and Use of Programmed Learning Materials," <u>NEA Journal</u>, April, 64, p. 28.

[2]Ibid

functions or for partial instruction. The decision to use programmed materials rests with all the people responsible for making a general policy decision; however, the classroom teacher is the one to decide if a program is to be used in a particular course. The teacher is the person who should select a particular program.

The selection of a program for a particular course requires deliberate preparation. To make a satisfactory selection it is necessary for the teacher to study, test, and evaluate the program. The teacher should consider, depending upon the school situation, that the program may be used in a classroom, in a study hall, at home, or in a special center for programmed materials. Teachers should decide how a program is to be used when different programs are being evaluated. The program may be used as a basic part of class work, as remedial work, or to enrich the regular work.

Murphy and Goldberg (22) state that programmed instruction is being successfully used in the business world. Companies of all sizes use programs and find important advantages in using them. Management makes use of the program to help bring specified achievement levels up to a certain point. IBM, Schering, Du Pont and Bell Laboratories report a gain in performance when programmed instruction is compared to conventional instruction. Some industries look upon the techniques as a powerful tool to influence on-the-job behavior and for bringing the levels of employees' skills and abilities up to the requirements of the jobs they are assigned.

Feldhusen (14) indicates that a logical question to ask is this: Is programmed learning material in any way more effective than simpler narrative presentations by text, teacher, or television? According to

Feldhusen, a growing tide of research evidence, classroom experience, and personal sentiments suggest a "no" to the preceding question. We find a conflict in what is reported to be true in industry and what is reported to be true in the school situation when program learning is considered. The reinforcement principle is most sacred to the theory underlying programmed learning. Instead of reinforcement some researches found signs of boredom when programs were used. The signs of boredom and dissatisfaction were sufficiently great to indicate that the program would not be a uniformly reinforcing experience to all youngsters.

An advantage claimed for programmed learning is that differences in aptitudes or intelligence can be reduced or eliminated as factors in learning. The claim has been made that children at various levels of mental ability would learn equally well from the program. Recent research evidence indicates that this is not true. As with most learning materials, able youngsters learned more and learned more rapidly with the programmed material. Programs have been found to be more suitable for bright and more verbally able youngsters.

Researchers such as Feldhusen (14) and Silberman (47) found learning just as effective when all learning principles incorporated in programmed instruction and claimed as advantages were stripped away. They found that students can still learn well from narrative instructional material.

Stalurow (49) states that the problem facing enthusiasts in the field of programmed learning is getting teachers to accept and use programmed materials. A review of the literature indicates that rather than get teachers to accept or use programmed materials they should be cautioned to proceed slowly. They should be urged to question excessive claims. Stalurow deplores attempts to compare teaching programs with a live teacher because of research difficulties controlling variables which may affect the outcome. Researchers agree that this is a problem; however, most of them suggest that we not retreat from the problem because of experimental difficulties. Every effort should be made to determine if learning from programs is as effective as learning from a live teacher or other available mediums. Studies should be made to determine what things the program can teach well and what must be left to the teacher. To determine how a program can best be used with pupils, it is necessary to make comparisons between the teacher and the program.

The acid test of any educational innovation can take place in only one place, the school use of the materials in actual classroom conditions. A survey was carried out by the Center for Programmed Instruction under a contract from the United States Office of Education to report the reaction of school systems which were using programmed materials. Over 2,000 school superintendents replied to the questionnaires sent during the survey. The administrators were asked to evaluate reaction in their own systems on a five point scale with these five categories: enthusiastic, favorable, neutral, opposed, strongly opposed. They were asked about the reactions of teachers, administrators, board of education, students, and parents. The results were as follows: Some answers were omitted so the percentages do not add to 100.

> Teachers: 22 per cent enthusiastic; 55 per cent favorable; 15 per cent neutral; 5 per cent opposed; less than 1 per cent strongly opposed.

Administration: 30 per cent enthusiastic; 53 per cent favorable; 1 per cent opposed; none strongly opposed.

Boards of Education: 12 per cent enthusiastic; 45 per cent favorable; 19 per cent neutral; 1 per cent opposed; and none strongly opposed.

Parents: 12 per cent enthusiastic; 37 per cent favorable; 23 per cent neutral; 3 per cent opposed; none strongly opposed.

The favorable response to programmed materials indicates that the materials have been well received by those school systems using them. The response does not indicate that an educational panacea has been found.

Educators are not in agreement as to the value of the teaching machine or programmed learning. The acknowledged father of the teaching machine, Sidney L. Pressey, professor of education at the University of Arizona, has some second thoughts about the uses now being made of teaching machines or programmed material. He is inclined to think they have become monstrosities. Pressey expresses his objections as follows:

> "Orthodox programming, as it has developed in recent years, is no more productive of learning than silent reading of materials dealing with the same substance, and silent reading takes less time.
>
> A useful alternative, incisive and time saving, is presentation to students of challenging questions which lead them to correct responses.
>
> 'Feedback' information, which comes automatically in programmed materials, is a useful adjunct to established educational processes but need not be fragmented, as it is when it comes through the program textbook or teaching machine." [3]

---

[3] Sidney L. Pressey, "A Puncture of the Huge Programming Boom?," Teacher College Record, February 1964, p. 418.

Comparative Studies

Pressey (44) says reviews of the most adequate research show programmed learning often to be no more efficient than the usual study-reading approach and almost always more clumsy and expensive. He tells of some experiments of his own which support this conclusion. By filling in blanks in several sections of a program dealing with the analysis of behavior, Pressey translated these into simple discourse. Groups of students studied the materials separately; some, using programmed materials; others, the translations. Those who studied the translations learned as much, and in one fifteenth of the time required to go through the program material. This experiment indicates that students learn very rapidly from silent reading without overt responding as required in programmed instruction.

After months of testing, Coronet Learning Programs reported that the results indicate that a significant increase in learning took place in all of the classrooms involved. Testing was conducted in fourteen states, twenty-eight schools, and with 1,590 students.

Reactions of educators to Coronet Learning Programs were reported as enthusiastic. The short-unit approach, the handy, inexpensive format, and the basic educational content have all been given high appraisals.

Schools in the Coronet study were requested to assign the use of the program at random to any suitable classroom rather than select teachers already experienced with the use of programmed materials. The teacher first administered the pre-test. Then the program was assigned. In some schools it was done as regular classwork, and in others, as homework. After completion of the program by the entire class, post-tests were given. The teacher returned the packet for evaluation. For each participating class, pre-test and post-test scores were entered for each student, and his gain calculated. Average scores were computed for the class. These scores were then subjected to standard procedures to determine their statistical significance. The percentage of possible gain was a measure used in the Coronet Experiment. Coronet reports that the comparatively new measure is becoming more widely used in the field because it is less influenced by extraneous factors. It is determined by dividing average gain by the possible gain. The possible gain is the difference between the possible score and the average score on the pre-test.

Coronet reports that all obtained results are statistically significant. The observed gains are much greater than can be accounted for by chance. On all of their programs except one, Latitude and Longitude, the percentage of possible gain was equal to or exceeded fifty per cent. Data obtained from the testing demonstrated a significantly high level of student achievement resulting from actual classroom use of Coronet Learning Programs.

Encyclopedia Britannica Films, Inc. have reported several case history reports when Temac Programmed Learning Materials have been used. These reports are concerned with the teaching of Algebra I.

A report is given on the teaching of an Algebra I summer class at Nutley, New Jersey, High School. Mr. Max Kletter was the teacher. The study period was five days weekly from 8:00 A.M. to 12:00 noon for six weeks in July and August, 1962. The class was composed of seventeen boys and girls, most of them about to enter the twelfth grade. Three had been graduated from high school the month before. The majority had been taking non-academic work and wanted to complete Algebra I to be eligible to enter an academic program in September. The three June graduates wanted to pass the course to meet college entrance requirements.

Each student was given his own Temac Algebra I programmed notebook. Progressing at his own rate, he worked through the text and was tested at the end of each unit of the course. Mr. Kletter kept a log of the number of frames completed by each student each day as a check on students' work habits. Students were allowed to take the course materials home at night and on weekends. Mr. Kletter found no boredom, and reports the class worked up to the closing bell. Students liked the material and enjoyed the feeling of discovery when they worked a frame and found they had given the correct answer. The teacher did not collect papers and did not have a problem with cheating. Mr. Kletter spent a great deal of time with individual students. He broke up the four-hour class period with discussion and some blackboard work. A break was taken at 10:00 A.M. each morning.

At the end of six weeks, students were given the Lankton First Year Algebra examination. Fourteen students passed, and three failed. Mr. Kletter reports that this was about the same as the failure rate for the regular one-year course and below the failure rate expected when students take a year of algebra during a six-weeks' summer class. Five students scored in the top ten per cent, and half were in the top twenty-five per cent, according to the national norms. All but five students were above the national means. Only two students fell below the fortieth percentile and one, who had failed first year algebra two years ago, scored at the ninety-eighth percentile.

The teacher observed that the class did very well and that the programmed course instilled good work habits. The student sees the entire program before him, and he knows how much he has to do. Mr. Kletter stated that the student has to learn by himself, and this is the best way to learn. The students stayed with a problem until they were successful in working it and they reported a wonderful feeling when they finally looked at the answer and saw they had it right. The teacher thought that the program allowed him to make better use of his time and that dull classroom drill was avoided. Mr. Kletter reported that a strong teacher with a wide background in mathematics is needed for the program. He observed that it would be practical to have a class where some students could be working on algebra and some on trigonometry in the same room. He further observed that bright students could do two years of algebra in one year with programmed materials.

A case history report from Harding Junior High School, Lakewood, Ohio, with Mr. Paul McGarvey, the teacher, reports similar results. The study period is five days weekly from 8:00 A.M. to 10:00 A.M., for six weeks during the summer session of 1962. The class was composed of sixteen boys and three girls with average I.Q. of 105.8 and I.Q. range 92-118 as scored on Otis Quick Scoring Beta. Thirteen students had completed algebra during the 1961-62 school year with below average scores. The average for these students on the Cooperative Elementary Algebra Test, Form Y, was in the sixtieth percentile nationally. The range was from the twenty-seventh through the ninety-eighth percentiles. The thirteen students wished to review their knowledge of ninth grade algebra. The remaining six students had completed ninth grade general mathematics, which included one semester's work in elementary algebra. They wished to complete their ninth grade algebra credit.

Each student was given his own Temac Algebra I programmed notebook. Students progressed at their own rate and answered questions from the text. After completing a specified number of pages he was tested on the material he had covered. The teacher spent most of the class time checking individual students' progress and answering individual students' questions. As tests were completed, they were immediately graded and discussed individually with each student. Mr. McGarvey considered his most important role to consist of motivating each student to progress at his own rate, and of enriching the learning of faster students. Twenty-minute discussions implementing the materials covered were led by the teacher at intervals during each week.

The students had no difficulty utilizing the Temac Programmed notebook. At the end of the first week, the class had completed an average of 180 pages of the total 1,292 pages of the entire course. The range was 113 pages to 269. Each student spent approximately ten hours in class and an average of less than two hours on outside study. At the end of the summer session two students had completed the entire course, ten had completed at least 75 per cent of it while four were unable to reach the halfway point. With the exception of two students, test scores were average or better.

The Cooperative Elementary Algebra Test was given at the end of the summer session. The thirteen review students had taken a form of this test when they completed algebra in the ninth grade. The median score for this group rose from the fifty-ninth percentile to the ninetieth percentile. The mean rose from the sixty-first to the seventy-fourth percentile. Eleven students showed substantial improvement, one showed no improvement, and one did more poorly. The median score for the six other students was at the forty-second percentile while the mean was at the forty-fifth.

Student reception of the programmed instruction was reported as favorable. Motivation and discipline problems did not exist. Most of the class would arrive early to begin their work in algebra. The majority of the students felt that the time passed rapidly. Faster students said they were relieved by the fact they did not have to listen to explanations of material they already knew. Slower students appreciated the opportunity to spend as much time on a particular topic as they needed. Two students expressed opposition to programmed instruction. They found it boring and monotonous. One achieved high test scores, and the other showed no improvement.

The teacher's comments were favorable. He reported that many students would report early for class and would work steadily until the end of the regular two-hour period. He observed that in the class with a relatively narrow ability range, the rate of individual progress was outstanding.

At Manhasset, New York, the Manhasset Junior High School conducted an experimental study using Temac Programmed Learning Materials. Twenty-six students were in the experimental group. The median I.Q.

of the control group was 104 while the median I.Q. of the experimental group was 105. According to teacher judgment the ranges in social maturity and in emotional adjustment were about the same in both groups. The experiment was conducted as a means of perhaps improving the provided course in elementary algebra designed to meet the needs of those pupils who have experimenced difficulties in mathematics in grades seven and eight who desire to move at a slower rate. It is customary in this school system for similar students to take three years to cover the work of elementary algebra and plane geometry rather than the customary two years.

Each student in the experimental group was furnished with program material and used this material in the classroom only. There was no outside assignments and no homework. Pupils were encouraged to work at their own rates with little or no assistance from the instructor. In the control group the teacher assumed the conventional role, and the class had daily homework, daily drill, and frequent testing.

At the end of the semester, the control groups and the experimental groups were tested. The control group had gone from a percentile rate of sixteen to one of forty-eight while the experimental group had gone from a percentile rating of thirty to thirty-three. The Lankton test form AM was used as a pre-test for the second semester. The median for the experimental group was the twenty-fourth percentile, while the control group was at the thirty-first percentile. When the final test was given using Lankton Form BM the experimental group had gained while the control group had lost. The experimental group had gone from the twenty-fourth percentile at midyear to the thirty-first percentile at the end of the school year while the control group had gone from the thirty-first percentile to the twenty-eighth. No student in either group completed the course.

At the end of the experiment, over half of the students in the experimental group asked permission to use the programmed material over the summer and to take a test in September with the intent of going into plane geometry classes the following year. Toward the end of the last semester, pupils were asking for more help, and their questions were meaningful and to the point. It was concluded that some of the students developed considerable self-reliance and gained a much better understanding of the process of independent study.

A questionnaire given the students in the experimental group indicated that about one third of them would prefer to have programmed courses while another one third preferred the conventional manner of teaching, and the other one third could not decide. Fifty per cent of the class felt that the Temac materials were clearly better than other courses they had taken in mathematics; twenty-eight per cent felt they were as good; approximately eighty per cent of the students felt that occasional lectures were a necessity. The students in the experimental group liked the idea of being able to work on their own, without homework, and with the individual attention of the teacher when it was necessary. Half of the students mentioned that the work was so well organized that they needed little help from the teacher.

The school administration decided that the use of programmed material should be continued with the slow learner. The administration felt that this material offered considerable promise in use with their regular classes.

Another report from Manhasset indicates that there was not a significant difference in achievement when Temac was used. This study was with a "dedicated" class of 24 students who were weak in mathematics and in general achievement. Temac was used with 12 of the children while the other 12 received the usual instruction. Two of the children using programmed materials completed the work in algebra in one year instead of the year and a half the decelerated group normally required. They were able to join and keep up with the regular group for the geometry part of the program and so save one year's work in mathematics.

When the entire school system, K-12, changed to the new mathematics, the use of Temac was discontinued. The rather expensive equipment is now unused. The program, consisting of a highly specific series of steps, could not be changed to the new mathematics program.

At Roanoke, Virginia, 475 students were involved in a study using Temac. Each student in the experimental classes was given his own Temac program and was allowed to progress at his own pace. No homework was permitted. The teacher's role varied as to whether she was working with a help or no-help class.

The students' reaction when asked if they would care to take another course using programmed materials was this: seventy-one per cent answered affirmatively, fourteen per cent answered negatively, and fifteen per cent indicated that they were undecided. The students expressed a desire to work on the material outside of class hours as well as in class. They also felt that it would be advisable for the teachers to give occasional lectures rather than have only programmed material. The students liked the idea of working at their own speed, and they stated that the material was organized so that they could easily understand it. Over ninety per cent of the students in those classes where programmed materials were used on a help basis were pleased that the teacher was able to give them individual help whenever they needed it.

The teachers involved in the project indicated that they would prefer to use programmed material to conventional material the following year. The concensus of the teachers, based on teacher-made test and classroom observations was that the students who had used program materials had learned more, showed greater independence, and had a better understanding of underlying principles than the students who had utilized the conventional material. The teachers thought that their contribution to the students using the program in the help classes was greater than their contribution to the students in conventional classes.

When the Lankton First Year Algebra Test was administered, it was found that the students who had used programmed materials were superior to the students using conventional material. The teachers realized that the findings must be tempered by the possibility that they can be explained not by the use of a program, but by a novelty effect of the Hawthorne variety. The researchers agreed that further research is needed. The Roanoke School System found the results so promising that programmed materials were purchased for approximately one third of the students for the school year 1961-62.

SUMMARY

Programmed instruction is bringing new horizons to the classroom and also many new headaches. At least in some areas of study the evidence indicates that carefully prepared and tested programs can be an aid to classroom learning. It is the quality of the program that matters, and it makes little difference in the learning situation if the program is in a machine or a programmed textbook. The literature indicates that the prospect of a lush school market is tempting some publishers to overlook quality and that they are more concerned with promotion of programs than preparation of the programs.

The Educational Testing Service of Princeton, New Jersey, is attempting to help educators sort out conflicting claims and avoid costly mistakes in selecting programmed learning materials. Studies are made of programs to determine if the content is up to date and worthwhile, whether the program meets the standards of technical excellence, and whether there is evidence that students learn from a given program.

A variety of programmed materials is becoming available. In evaluating the specific content which a self-instructional program purports to teach, the program should be examined to determine what the student is required to do and whether this reflects the kind of competence which educators wish to achieve. Just any set of question and answer material does not constitute a self-instructional program. Items in a step-by-step program are designed so that the student will respond to the critical aspect of each item. Programmed materials are designed to adapt to individual differences by allowing each student to proceed at his own rate. Questions should be designed to diagnose the students' needs and to lead into material suited to those needs.

The advocates of programmed learning claim that the materials can be used to extend the curriculum without any addition to the staff, that gifted students can often do as much as two and one-half years of mathematics in one year's time, that slow students have the opportunity to master the subject at their own pace, that flexibility in scheduling becomes a reality, with no need to stagger the mathematics offering from year to year. The claim is made that programmed learning materials are economical because all of the above advantages are secured without the additions to plant or staff.

Producing a specialized program whether for industry or the classroom requires time and money and a well trained staff. Many school systems are producing their own program materials. From past experiences they are taking a good look and making a thorough study of programs on the market for sale. Management and education are making use of programmed instruction, but a broad segment of top management and educators remain skeptical about automated learning. Some psychologists say that programmed education reduces teaching to an exact science. Teachers ask, will this new technique produce creative minds or well drilled robots?

A summary of the values of programmed instruction are the following: (1) The pupil is continuously involved in the learning process. He must answer questions in order to proceed. (2) The pupil immediately knows if he is right or wrong. (3) Each pupil proceeds at his own rate of speed. (4) Individual instruction becomes a reality.

More information is needed about programmed instruction in the following areas: (1) In what capacity is it most useful? (2) How effective is it? (3) In what areas will it find its fullest application? (4) Can pupils with conventional study skills make satisfactory use of programmed materials?

Research studies indicate that pupils learn when programmed materials are used. There are few reports comparing achievement when the conventional methods and the program technique are used. School systems should carry out active experimentation with self-instructional materials before making large scale adoptions.

CHAPTER III

METHODS AND PROCEDURES

Design of the Study

Eighty-four Algebra I students in the ninth grade at West Junior High School, Ponca City, Oklahoma, were involved in the project. The students were divided into three groups with twenty-eight in each group.

The teacher served as a resource person in the class using programmed materials. Each student using a program progressed at his own pace, and the teacher was available to give instruction when the individual student made a request. The formal lecture period or the group discussion technique was not used in conjunction with the program. Teacher-made tests and tests prepared by Encyclopedia Britannica to be used with Temac were administered as students became prepared for them.

In the class using the program each student was with the teacher when each of the tests was graded. Errors were discussed with the student as the test was scored, and each student was required to achieve a raw score of 60 before proceeding to the next test.

Grouping was used to the extent that a student who was progressing at a rapid pace was placed with a group of slower students. He was available to help members of the group with any problems they did not understand.

Form BM of the Seattle Algebra Test was given to all students finishing the semester's work before the scheduled end of the semester. When a student completed the first semester, he went immediately to the work for the second semester. The teacher prepared a diary for the class using the program. Students were allowed to work with the program outside of class time. Groups B and C used traditional textbooks and approached the learning of algebra by the use of conventional methods.

Standard scores made by the students were used for comparisons. The data obtained was subjected to statistical procedures to determine if there was a significant gain in achievement.

Group A used programmed materials in the study of Algebra I. Groups B and C used conventional teaching methods. The three groups consisted of students with comparable mathematical abilities. The selection of students was determined by scores made on the Orleans Prognosis Test for Algebra I and the Henmon-Nelson Test of Mental Ability. Using the split-half method the reliability of the Orleans Test is .92. The students and methods of instruction were randomly assigned to groups. Groups A, B, and C were taught by the same teacher at West Junior High School. The instructional periods were fifty-five minutes long and met five times per week for eighteen weeks.

The null hypothesis was tested at the .05 level of significance. The scores made by the students on standardized algebra tests were compared by the t. test and analysis of covariance.

At the beginning of the first semester form AM of the Seattle Algebra Test was administered to the students of each group. The student was examined in vocabulary, fundamental processes, equations, algebraic representation and problems. The reliability of this test is .87 using alternate forms. At the end of the semester form BM of the Seattle Test was administered to each student.

An attitude scale was given at the beginning and at the end of the instructional period. Statistical techniques were used to compare the before-and-after scores.

Assumptions of the Study

It was assumed that the two teaching methods would be successful in the teaching of algebra. It was also assumed that differences in achievement would occur and that each group would achieve. Also the attitudes of students would change significantly when different teaching methods were used. The null hypothesis was accepted to be operational in this study.

Personnel for the Study

All of the eighty-four students involved in the study completed the eighth grade course in mathematics at West Junior High School. All of them received instruction from the same eighth grade mathematics teacher. The students received instruction from the same algebra teacher in the ninth grade.

The distribution of the students in this study is shown in Table I.

TABLE I

CLASSIFICATION OF STUDENTS INCLUDED

IN THIS STUDY

	Type of Eighth Grade Mathematics	Type of Algebra	Time of Instruction	Sex M.	Sex F.	Total
Group A	Conventional	Teacher plus the program	10:26-11:23 A.M.	11	17	28
Group B	Conventional	Conventional	12:20--1:15 P.M.	12	16	28
Group C	Conventional	Conventional	1:20--2:15 P.M.	13	15	28

Subject Matter Organization

The textbook used was A First Course in Algebra by W. W. Hart. In the first nine weeks of the semester the students studied general numbers, linear equations, signed or directed numbers, and monomials with one week being taken for reivew and remedial work. The students studied polynomials, linear equations with one unknown, simultaneous linear equations, and special products and factoring during the second nine weeks. The programmed materials included similar problems and material. In the class using the program the students were not regimented as to the time they would spend on a particular topic. For example, in the conventional classes two weeks were assigned for the study of linear equations. In the class using the program students could spend one to three weeks on linear equations.

Measuring Instruments

The Henmon-Nelson Tests of Mental Ability and the Orleans Algebra Prognosis Test were used in an attempt to determine three groups of students with comparable ability in mathematics.

The Henmon-Nelson Test of Mental Ability contains ninety items to be completed in 30 minutes. The mental age, percentile rank and I.Q. can be determined from the test results. Care was used in the construction and selection of items to avoid using those that might appeal more to one sex than to the other. A random sample of two hundred boys and two hundred girls aged twelve was obtained from the entire population; neither the means nor the standard deviations of the test scores for these two groups was significantly different at the 1 per cent level. Congruent validity is demonstrated by a correlation coefficient of .776 with the Otis; .798 with the Lorge-Thorndike; .760 with SRA Primary Mental Abilities and .794 with Kuhlman-Anderson. The predictive validity of the Henmon-Nelson Test is demonstrated by a correlation coefficient of .699 with the test on quantitative thinking in the Iowa Tests of Educational Development. Using alternate forms, the reliability coefficients are established at .867 and .906.

The Orleans Algebra Prognosis Test was developed by Joseph B. Orleans, chairman of the Mathematics Department, George Washington High School, New York City. The test gives an estimate of a student's probability of success in first year algebra. The revised edition is a revision of the original test in use for over twenty years. "The test attempts to measure those abilities that lead to success in learning algebra. These basic elements involve (1) an appreciation of the use of symbols to represent numbers, (2) the ability to substitute values for these symbols, (3) the ability to represent quantities by means of symbols and to use them, (4) the ability to express relationships by means of symbols, and (5) the combination of all the above in solving problems."[1]

The test is divided into eleven parts, and each part is timed. The actual working time for the test is thirty-nine minutes. Complete administration calls for forty-five.

The validity of a prognosis test is evaluated in terms of the effectiveness with which it aids in the prediction of the degree of success one will achieve in a certain area. An r of .82 was obtained between prognosis test scores and scores made on the Columbia Research Bureau Algebra Test when these tests were administered to three hundred beginning algebra students in George Washington High School, New York City. An r of .71 was determined when similar comparisons were made of the test scores of 250 students in two New York City high schools. The Orleans Test, Revised Edition, was administered to 322 beginning-algebra students in one school and 119 students in another school. The Seattle Algebra Test was administered to 278 and ninety-four of the same students at the end of a half-year of study. The correlations between the prognosis and achievement test scores were .60 and .59 respectively.

A corrected split-half reliability coefficient of .92 was obtained by correlating the odd and even items on the tests of 411

[1]Joseph B. Orleans, "Orleans Algebra Prognosis Test," Manual of Directions, World Book Company, New York, p. 3.

beginning-algebra students in a single community. The standard error of measurement on the Orleans Algebra Prognosis Test is 4.2 raw score points.

Based on the data obtained in the preliminary research a prognosis score of 62-98 will indicate that chances for success in algebra are very good. A score in the range of 25-61 indicates a good chance to do average work. A score 0-24 indicates that the student is a poor risk and will likely fail under ordinary instructional provisions.

The Seattle Algebra Test for the end of the first half-year of Algebra I was developed by Harold B. Jeffery, supervisor of research in Seattle Public Schools. The test was designed to measure the achievement of students in the important objectives of the first half-year of a high school course in beginning algebra. There are two comparable forms, AM and BM, each comprising forty-seven test items selected on the basis of curricular validity and satisfaction of statistical requirements. The time required for administration of the test is one class period. The test measures knowledge and understanding of the facts of beginning algebra and the application of acquired skills and methods. There are four parts to the test. Part A consists of nine items, nineteen per cent of the total items, and is on vocabulary. Part B considers fundamental processes and includes twenty-one items or forty-five per cent of the test items. A test on equations is included in Part C consisting of nine items which is nineteen per cent of the total test. Algebraic representation and problems make up the eight test items found in Part D. The items in Part D represent seventeen per cent of the overall test items.

The test items found in the Seattle Algebra Test were constructed after a thorough analysis of varied instructional materials and authoritative pronouncements in the mathematics field. The elements measured may be justified in terms of frequency of inclusion in commonly used textbooks and on the basis of expert judgment as to importance. Test scores obtained from the testing of 6,500 students over a three-year period were used to determine the two final forms of the test. The forms were balanced in difficulty, extended over a suitable range of difficulty, and composed of items known to be of significant discriminating power.

The reliability of the Seattle Algebra Test is demonstrated when correct split-half reliability coefficients, based upon test results from 164, 128, and 84 students in separate communities were obtained. An alternate form reliability of .87 was found on administration of both forms AM and BM to students in one community, with an interval of less than a week between the successive administrations. The standard error of measurement on the Seattle Test is four standard score points. Form AM and BM are comparable in content in the sense that their respective items cover in approximately equal proportions the various aspects of the subject with which the test is concerned.

The attitude scale toward mathematics was developed by Nicholas Kushta when he was doing graduate work at the University of Chicago. The scale consists of forty-five weighted items. The items were weighted by nine judges at the University of Chicago. The arithmetic mean of the nine weights given by the judges was the final weight of the item. The coefficient of concordance, the agreement in ranking of the items by the judges, was .93. The reliability of the attitude scale was established by test-retest of thirty-five ninth grade students at Lindblom High School in Chicago on successive days. The Pearson Correlation Coefficient obtained was .98.

In administering the attitude scale the student is instructed to list those statements which he accepts as reflecting his attitude. The arithmetic mean of the weights of the statements on the student's list gives a numerical score which characterizes the student's attitude. The lower the arithmetic mean is found to be, the more favorable is the attitude toward mathematics.

Statistical Methods

The analysis of covariance was the method of statistical analysis used to test the hypotheses concerned with achievement in Algebra I as related to method of instruction and related variables. This technique is especially useful for testing differences in academic achievement. The analyses of covariance was used to control the influence of I.Q., Orleans Prognosis Test, and the algebra pre-test results on algebraic achievement. The analysis of covariance provides for a measure of control of individual differences and incorporates the elements of the analysis of variance and regression. The method takes into account the variable characteristics other than the criterion. Analysis of covariance serves as the final statistical judgment in determining the significance of achievement.

Chi Square was used to determine if there was a significant difference in the choice of teaching methods at the end of the instructional period. This method of statistical analysis was also used to determine if there was a significant change in the attitude of students toward mathematics. Chi Square contrasts the difference between observed or obtained results with those results theoretically expected. This technique uses ordinal or nominal level of measurement and is nonparametric.

CHAPTER IV

RESULTS OF THE STUDY

Report From the Diary

The teacher kept a daily diary in which he made observations concerning the attitudes of students' progress in the three classes. The students in the class using programmed materials enthusiastically accepted the program and the idea of program teaching. The reports from parents and students were favorable to the use of Temac in the approach to the learning of algebra.

In the first four weeks of the school term all students made satisfactory progress and were working with enthusiasm. It was observed by the teacher that programmed material had an important advantage when students were absent. It was easier for them to make up back work or to be up with the other students when they returned to class.

During the sixth week of instruction the students in the class using programmed materials were having trouble with signed numbers. At this time it was observed that the other classes are farther along in the course than the program class. Another observation was that a few students using the program were losing their initial enthusiasm.

At the end of the seventh week the range in frames completed was from 1489 to 3156. The slow students had a tendency to work at a still slower pace. Competition seemed to be missing in the programmed class, and some students were having difficulty in remembering what had previously been presented. This was not an exclusive characteristic of the class using Temac, but was more pronounced than in the conventional classes. The conventional classes were having better success than the experimental class in solving equations involving fractions. Mr. Lewis, the teacher, was of the opinion that the conventional classes had covered more material. He believed his work with the program had improved his teaching of the regular algebra classes.

At the end of the nine weeks' grading period the letter grades given by the teacher were considerably higher in the program class. It was observed that the tests that came with Temac were probably easier than the teacher-made tests used in the conventional classes. The students using the program were observed to be slowing their pace. This was possibly due to the problems becoming more difficult. Many students in Group A were having difficulty with substituting polynomials. This was not observed in Groups B and C. The range of work covered by individual students was getting greater in the programmed class. The teacher stated that ungraded papers had become a problem.

In the eleventh week of the instruction period the parents attended "Back-to-School" Night. All of the parents who were present seemed to accept the use of the program. However, it was observed that no parent presented an opinion if the program was good or bad. At this time the range in frames completed by students ranted from 1,971 to 4,500. Subtraction, multiplication, division of exponents were giving Group A more than the usual amount of difficulty. Approximately twenty per cent of Group A was behind the progress of students in Groups B and C.

During the thirteenth week one student using Temac completed the semester's work. He took the semester test at this time and made a standard score of 134. This was a gain of thirty-eight points over his pre-test score. To complete the first semester's work, a student was to complete successfully the first fifteen tests that come with Temac. In contrast to the one student who had completed all of the tests during the thirteenth week, there was one student who had not completed Test 6 and four students who had not completed Test 7. In this week of instruction three students took Test 11 and one student took Test 12.

One half of the students had completed Test 11 by the fifteenth week. During this week a student who had made the most progress in algebra was assigned to work with two slower students. This was an attempt by the teacher to help the slow student. Mr. Lewis observed that the programmed material gave a good explanation in regard to graphing. The conventional classes had completed the work on simultaneous equations and that one half of the students using the program had reached this point.

At the end of the Christmas holidays several students in Group A were ready to take two or three additional tests. It was observed that the students using the program had worked more on algebra during the vacation period than the students in the conventional classes. The grouping of students in small study groups was a help to both the slow and fast student. Groups were observed as being in competition with each other, and more material was being covered.

During the last week of the semester the students in Group A were having difficulty with factoring. At this time many of the slower students using the program were getting discouraged and were in need of encouragement from the teacher to continue the work. There were days when the teacher would have been glad to have discarded the program approach to the teaching of Algebra I. Mr. Lewis stated that there is not a sense of reward or self-appraisal for the teacher's benefit even if the student does a good job in a particular area.

Three students in the programmed class completed the first semester's work before the scheduled time. The spread of frames completed by students at the end of the semester was from 3,655 to 5,700 or a difference of 2,045.

At the end of the semester the teacher preferred the conventional method of teaching Algebra I. The use of the program created much more work for the teacher in the grading of papers and in providing more individualized instruction. Mr. Lewis stated that he was in need of a grader or a secretary if he were to do quality teaching. Slow students using the program had a tendency to get slower and lose interest when they realized that they were not keeping up with the progress made by classmates. The program was criticized for not being consistent in the coverage of important information. Some topics received much attention while others were given only a brief treatment. The good student was observed to get bored with needless repetition of information after he had received all of the necessary instruction. However, this repetition is desirable for the slower student. The better students had the impression that they repeated much work that was not necessary.

Tests of Stated Hypotheses

Hypothesis I. There will be a difference in the achievement level of Groups A, B and C at the end of the first semester.

Table II shows the mean gain score in each group, mean I.Q.'s and mean scores on the Orleans Prognosis Test. As a criterion the first semester gain scores as measured by the Seattle Algebra Test were used. Since the academic ability and the mathematical ability could conceivably influence each student's response to the criterion, these individual differences were controlled by obtaining the Henmon Nelson I.Q. scores as a measure of academic ability and the scores made on the Orleans Prognosis Test as a measure of mathematical ability for each student in the sample. By using these scores as control variables in the analysis of covariance, the possible bias introduced by individual differences was removed in so far as those factors adequately represent the differences in question. The information in Table II indicates that each group experienced a gain in achievement. The group using programmed materials had a mean gain of 17.46 standard scores. The groups using conventional procedures in the study of Algebra I had mean standard score gains of 31.86 and 22.92. The mean gain of the three groups of students was 24.08 standard scores. The mean I.Q. of the eighty-four students in the study was 110.89 and the mean standard score on the Orleans Prognosis Test was 64.29.

TABLE II

SUMS AND MEANS OF THE CRITERION AND CONTROL VARIABLES FOR ALGEBRA I STUDENTS

Number		Gain in Achievement Algebra I		I.Q.		Orleans Prognosis	
	N	$\sum Y$	$\bar{Y}$	$\sum X_1$	$\bar{X}_1$	$\sum X_2$	$\bar{X}_2$
Group A	28	489	17.46	3108	111	1833	65.46
Group B	28	892	31.86	3127	111.68	1752	62.57
Group C	28	642	22.92	3080	110	1815	64.82
Total	84	2023	24.08	9315	110.89	5400	64.29

Table III presents a summary of the data relative to achievement in algebra during one semester. The sums of squares and the sum of all possible crossproducts are necessary for the computation and are shown in the following table. These values were found for the entire sample and not for the three groups individually.

TABLE III

SUMMARY OF EXPERIMENTAL DATA FOR STUDENTS IN ALGEBRA I

Scores	Symbols	For Entire Sample
Given in Algebra I	$\sum Y^2$	57,923
Henmon Nelson I.Q. Scores	$\sum X_1^2$	1,039,231
Orleans Prognosis Test for Algebra I	$\sum X_2^2$	360,364
Crossproducts	$\sum X_1 Y$	225,840
	$\sum X_2 Y$	131,633
	$\sum X_1 X_2$	603,470

Table IV shows the variation in the subgroups when the first semester's achievement is considered. The values in Table II and Table III were used to compute the sums of squares and the sums of crossproducts in deviation form for the total sample and for within subgroups.

TABLE IV

SUMS OF SQUARES AND CROSSPRODUCTS IN DEVIATION FORM FOR BOTH SUBGROUPS

Source of Variation	$\sum y^2$	$\sum x_1^2$	$\sum x_2^2$	$\sum x_1 y$	$\sum x_2 y$	$\sum x_1 x_2$
Total	9,202.4166	6,264.035	13,221.1428	1,503.7500	1,583.0000	4,648.5715
Within Subgroups	6,246.2501	1,769.8215	13,091.9286	1,323.7142	2,191.8928	4,696.1429

Table V shows the test for significance after the regression equations are calculated, and adjustments have been made in the sum of squares. A test of significance was made of the null hypothesis that there was not a significant difference in achievement of Groups A, B and C at the end of the first semester. The analysis of covariance is shown in Table V. The _F_-value of 80.7819 with two and seventy nine degrees of freedom is significant beyond the .01 level of confidence. The null hypothesis was rejected. Therefore, when the criterion means of the three groups were adjusted for individual differences in I.Q. and scores on the Orleans Prognosis Test, the difference was so large that it was not caused by a sampling accident. Presumably the difference in achievement can be attributed to the teaching procedures.

TABLE V

TEST OF SIGNIFICANCE OF INFLUENCE OF TEACHING METHOD ON ACHIEVEMENT IN ALGEBRA I

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares
Total	81	8,819.1017	
Within Subgroups	79	2,896.1551	36.6601
Difference	2	5,922.9466	2961.4733

$F = 80.7819, \quad p < .01$

Table VI demonstrates the t test for significance of differences among means after the criterion means have been adjusted for differences that cannot be attributed to the teaching method. To have a significant difference at the .05 level of confidence there must be a differential of at least 3.22. A differential of 4.26 must be reached at the .01 level to have a significant difference.

TABLE VI

SIGNIFICANCE OF DIFFERENCES AMONG ADJUSTED Y MEANS

$$S D y x = \sqrt{36.66} = 6.05$$

$$S E m y x = \frac{6.05}{\sqrt{28}} = \frac{6.05}{5.292} = 1.14$$

$$S E_d \text{ between any two adjusted means} = 6.05 \sqrt{\frac{1}{28} + \frac{1}{28}}$$

$$= 6.05 \times .2672 = 1.62$$

For df = 79, t.05 = 1.99; t.01 = 2.63

Significant difference at .05 level = 1.99 X 1.62 = 3.22

Significant difference at .01 level = 2.63 X 1.62 = 4.26

Table VII illustrates the significance of the differences between adjusted group means. The two groups that studied algebra using conventional teaching procedures experienced achievement that was superior to the group using programmed materials at the .01 level of confidence. There was a significant difference between the groups using conventional teaching procedures at the .01 level of confidence.

TABLE VII

SIGNIFICANCE OF ACHIEVEMENT AMONG GROUPS IN ALGEBRA I

Group	Adjusted Mean	$\overline{Yc} - \overline{Yb}$	$\overline{Yc} - \overline{Ya}$	$\overline{Yb} - \overline{Ya}$
C	29.36	5.83**		
B	23.53			4.28**
A	19.25		10.11**	

** Indicates significance at the .01 level

Hypothesis 2. There will be a difference in favorable attitudes toward mathematics, as exemplified by the students in each group at the end of the instructional period.

Table VIII indicates the attitude change toward mathematics of the eighty-four first-year algebra students as measured by the attitude scale. In the group using programmed materials the attitudes of twenty students changed to unfavorable toward mathematics. There were eight favorable changes in this group. In the groups using conventional teaching procedures there was a total of twenty seven students whose attitude change was unfavorable and a total of twenty-nine students whose attitude change was favorable. Using chi square as a statistical procedure to test the significance of the attitude change the null hypothesis was not rejected. The chi square value of 4.154 with two degrees of freedom is not significant at the .05 level of confidence. It cannot be presumed that the attitude change found in students was caused by the teaching procedures.

TABLE VIII

ATTITUDE CHANGE TOWARD MATHEMATICS AT THE

END OF THE FIRST SEMESTER

	Unfavorable		Favorable		
Group A	20	FE. 15.7	8	FE. 12.3	28
Group B	14		14		28
Group C	13		15		28
	47		37		84

$$\chi^2 = 4.154 \quad P. > .05$$

<u>Hypothesis 3.</u> There will be a significant difference in the ability to understand algebraic vocabulary at the end of the first semester.

Table IX provides the mean gain in achievement as measured by the Seattle Test on vocabulary. The criterion used was the gain scores as measured by the Seattle Algebra Test on vocabulary. The scores made by students on the Henmon Nelson I.Q. Test and the Orleans Prognosis Test were used as control variables. In the analysis of covariance, the possible bias introduced by individual differences will be removed in so far as those factors adequately represent the differences in question. Each group experienced achievement in the mastery of algebraic vocabulary. The group using programmed materials experienced the lowest achievement score as measured by the test.

TABLE IX

SUMS AND MEANS OF THE CRITERION AND CONTROL VARIABLES FOR ALGEBRA I STUDENTS' VOCABULARY

	Number	Gain in Achievement in Vocabulary			I.Q.	Orleans Prognosis	
	N	ΣY	$\bar{Y}$	ΣX	$\bar{X}_1$	ΣX_2	$\bar{X}_2$
Group A	28	362	12.93	3108	111	1833	65.46
Group B	28	373	13.32	3127	111.68	1752	62.57
Group C	28	368	13.14	3080	110	1815	64.82
Total	84	1103	13.13	9315	110.89	5400	64.29

Table X gives a summary of the data obtained from the vocabulary test. The sums of squares and the sum of all possible crossproducts are necessary for the computation and are shown in the following table. These values were found for the entire sample and not for either of the three groups individually.

TABLE X

SUMMARY OF EXPERIMENTAL DATA FOR STUDENTS IN ALGEBRA I VOCABULARY

Scores	Symbols	Total for Entire Sample
Gain in Algebra I	ΣY^2	14,697
Henmon Nelson I.Q. Scores	ΣX_1^2	1,039,231
Orleans Prognosis Test for Algebra I	ΣX_2^2	360,364
Crossproducts	$\Sigma X_1 Y$	122,341
	$\Sigma X_2 Y$	71,185
	$\Sigma X_1 X_2$	603,470

Table XI illustrates the data obtained from the vocabulary test in deviation form. The values in Table IX and Table X were used to compute the sums of squares and the sums of crossproducts in deviation form for the total sample and for within subgroups.

TABLE XI

SUMS OF SQUARES AND CROSSPRODUCTS IN DEVIATION FORM

FOR BOTH SUBGROUPS VOCABULARY

Source of Variation	Σy^2	Σx_1^2	Σx_2^2	$\Sigma x_1 y$	$\Sigma x_2 y$	$\Sigma x_1 y_2$
Total	213.5595	6,264.035	13,221.1428	26.1785	277.8571	4,648.5715
Within Subgroups	211.3939	1,769.8215	13,091.9286	22,8929	293.5000	4,696.1429

Table XII demonstrates the test for significance in achievement in algebraic vocabulary due to teaching method after the regression equations have been calculated, and adjustments have been made in the sum of squares. A test of significance was made of the null hypothesis that there was not a significance difference in the ability to understand algebraic vocabulary at the end of the instructional period. The analysis of covariance is demonstrated in Table XII. The *F*-value of 25.67 with two and seventy nine degrees of freedom is significant beyond the .01 level of confidence. The null hypothesis was rejected. Therefore, when the criterion means of the three groups were adjusted for individual differences in I.Q. and scores on the Orleans Prognosis Test, the difference was so large that it was not caused by a sampling accident. Presumably the difference in the understanding of algebraic vocabulary was caused by the teaching procedures.

TABLE XII

TEST OF SIGNIFICANCE OF INFLUENCE OF TEACHING METHOD ON ACHIEVEMENT IN ALGEBRA I VOCABULARY

	Residuals		
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares
Total	81	206.6152	
Within Subgroups	79	125.2307	1.5851
Difference	2	81.3845	40.6922

$F = 25.67, \quad P < .01$

Table XIII illustrates the t test for significance of differences among vocabulary means after the criterion means have been adjusted for differences that cannot be attributed to the teaching method. To have a significant difference at the .05 level of confidence there must be a differential of at least .66. A differential of .87 must be obtained at the .01 level to have a significant difference.

TABLE XIII

SIGNIFICANCE OF DIFFERENCES AMONG ADJUSTED Y MEANS

$$S.\ D.\ x. = \sqrt{1.5851} = 1.25$$

$$S.\ E.\ m = \frac{1.25}{\sqrt{28}} = .23$$

$S\ E_d$ between any two adjusted means $= 1.25 \sqrt{\frac{1}{28} + \frac{1}{28}}$

$= 1.25 \times .2672 = .33$

For df = 79, t .05 = 1.99; t .01 = 2.63

Significant difference at .05 level = 1.99 X .33 = .66

Significant difference at .01 level = 2.63 X .33 = .87

Table XIV demonstrates the significance of the differences between adjusted group means. Group B, using conventional teaching procedures, experienced achievement that was superior to the other conventional group and the programmed group at the .01 level of confidence. There was not a significant difference between the group using programmed materials and Group C.

TABLE XIV

SIGNIFICANCE OF ACHIEVEMENT AMONG GROUPS IN ALGEBRAIC VOCABULARY

Group	Adjusted Mean	$\overline{Yb} - \overline{Ya}$	$\overline{Yb} - \overline{Yc}$	$\overline{Ya} - \overline{Yc}$
B	14.72	2.12**		
A	12.60			.51
C	12.09		2.63**	

** Indicates significance at the .01 level.

Hypothesis 4. There will be a significant difference in the ability to use fundamental processes.

Table XV gives the mean gain in achievement as measured by the Seattle Test on fundamental processes. The mean gain in achievement of the three groups was 16.71 standard scores. Group A, using programmed materials, had a mean gain of 14.93. Groups B and C, the groups using conventional procedures to study algebra, had mean gains of 18.71 and 16.50 standard scores. The control variables are the scores made on the Henmon Nelson I.Q. Test and the Orleans Prognosis Test. By using these scores as control variables in the analysis of covariance, the possible bias introduced by individual differences was removed in so far as those factors adequately represent the differences in question, academic ability and mathematical ability.

TABLE XV

SUMS AND MEANS OF THE CRITERION AND CONTROL VARIABLES FOR ALGEBRA I STUDENTS IN FUNDAMENTAL PROCESSES

	Number	Gain in Achievement		I.Q.		Orleans Prognosis	
	N	ΣY	$\bar{Y}$	ΣX_1	$\bar{X}_1$	ΣX_2	$\bar{X}_2$
Group A	28	418	14.93	3108	111	1833	65.46
Group B	28	524	18.71	3127	111.68	1752	62.57
Group C	28	462	16.50	3080	110	1815	64.82
	84	1404	16.71	9315	110.89	5400	64.29

Table XVI gives a summary of the data obtained from the test on fundamental processes. The sums of squares and the sum of all possible crossproducts that are necessary for the computation are shown in the following table. These values were found for the entire sample and not for the three groups individually.

TABLE XVI

SUMMARY OF EXPERIMENTAL DATA FOR STUDENTS IN ALGEBRA I

FUNDAMENTAL PROCESSES

Scores	Symbols	Total for Entire Sample
Gain in Algebra I	$\sum Y^2$	24,588
Henmon Nelson I.Q. Scores	$\sum X_1^2$	1,039,231
Orleans Prognosis Test for Algebra I	$\sum X_2^2$	360,364
Crossproducts	$\sum X_1 Y$	155,900
	$\sum X_2 Y$	90,368
	$\sum X_1 X_2$	603,470

Table XVII illustrates the data obtained from the test on fundamental processes in deviation form. The values in Table XV and Table XVI were used to compute the sums of squares and the sums of crossproducts in deviation form for the total sample and for within subgroups.

TABLE XVII

SUMS OF SQUARES AND CROSSPRODUCTS IN DEVIATION FORM FOR BOTH SUBGROUPS' FUNDAMENTAL PROCESSES

Source of Variation	Σy^2	Σx_1^2	Σx_2^2	$\Sigma x_1 y$	$\Sigma x_2 y$	$\Sigma x_1 x_2$
Total	1,121.1428	6,264.035	13,221.1428	206.4285	110.8571	4,648.5715
Within Subgroups	918.5715	1,769.8215	13,091.9286	162.4286	269.0000	4,696.1429

Table XVIII demonstrates the test for significance in achievement in the fundamental processes of algebra after the regression equations have been calculated and adjustments have been made in the sum of squares. A test of significance was made of the null hypothesis that there was not a significant difference in achievement in the fundamental processes. The analysis of covariance is shown in Table XVIII. The F-value of 10.89 with two and seventy degrees of freedom is significant beyond the .01 level of confidence. The null hypothesis was rejected. Therefore, when the criterion means of the three groups were adjusted for individual differences in I.Q. and scores on the Orleans Prognosis Test, the difference was so large that it was not caused by a sampling accident. Presumably the difference in achievement can be attributed to the teaching procedures.

TABLE XVIII

TEST OF SIGNIFICANCE OF INFLUENCE OF TEACHING METHOD ON ACHIEVEMENT IN ALGEBRA I FUNDAMENTAL PROCESSES

	Residuals		
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	81	1,118.8134	
Within Subgroups	79	876.9683	11.1008
Difference	2	241.8451	120.9225

$F = 10.89, \quad p < .01$

Table XIX demonstrates the t test for significance of differences among mean scores in the use of fundamental processes after the criterion means have been adjusted for differences that cannot be attributed to the teaching method. To have a significant difference at the .05 level of confidence there must be a differential of at least 1.77. A differential of 2.34 must be reached at the .01 level to have a significant difference.

TABLE XIX

SIGNIFICANCE OF DIFFERENCES AMONG ADJUSTED Y MEANS

$$S.D._{y.x.} = \sqrt{11.1008} = 3.33$$

$$S.E._m = \frac{3.33}{\sqrt{28}}$$

$$S\,E_d \text{ between any two adjusted means} = 3.33\sqrt{\frac{1}{28} + \frac{1}{28}}$$

$$= 3.33 \times .2672 = .89$$

For df = 79, $t_{.05} = 1.99$; $t_{.01} = 2.63$

Significant difference at .05 level = 1.99 X .89 = 1.77

Significant difference at .01 level = 2.63 X .89 = 2.34

Table XX illustrates the significance of the differences between the adjusted group means. The groups that studied algebra using conventional teaching procedures experienced achievement that was superior to the group using programmed materials. There was not a significant difference between the two conventional groups. Group C had achievement that was significant at the .05 level of confidence when compared with Group A, the group using programmed materials. The achievement of Group B was significant at the .01 level when contrasted with Group A.

TABLE XX

SIGNIFICANCE OF ACHIEVEMENT AMONG GROUPS IN COMMAND OF THE FUNDAMENTAL PROCESSES OF ALGEBRA I

Group	Adjusted mean	$\overline{Yb} - \overline{Yc}$	$\overline{Yb} - \overline{Ya}$	$\overline{Yc} - \overline{Ya}$
B	17.73	.49		
C	17.24			2.07*
A	15.17		2.56**	

* Indicates significance at the .05 level

** Indicates significance at the .01 level

Hypothesis 5. There will be a significant difference in the ability to solve equations.

Table XXI gives the mean gain in achievement as measured by the Seattle Sub Test on equation solving. The criterion used was the gain scores as measured by the Seattle Algebra Test on equation solving. Each group experienced achievement in its ability to solve algebraic equations. Group A, the group using programmed materials had the lowest achievement score as measured by the test. The scores made by students on the Henmon Nelson I.Q. Test and the Orleans Prognosis Test were used as control variables. In the analysis of covariance, the possible bias introduced by individual differences was removed in so far as those factors adequately represent the differences in question.

TABLE XXI

SUMS AND MEANS OF THE CRITERION AND CONTROL VARIABLES FOR ALGEBRA I STUDENTS' EQUATION SOLVING

	Number	Gain in Achievement		I.Q.		Orleans Prognosis	
	N	ΣY	$\bar{Y}$	ΣX_1	$\bar{X}_1$	ΣX_2	$\bar{X}_2$
Group A	28	339	12.11	3108	111	1833	65.46
Group B	28	400	14.28	3127	111.68	1752	62.57
Group C	28	371	13.25	3080	110	1815	64.82
	84	1110	13.21	9315	110.89	5400	64.29

Table XXII gives a summary of the data obtained from the test on equation solving. The sums of squares and the sum of all possible crossproducts are necessary for the computation and are shown in the following table. These values were found for the entire sample and not for either of the three groups individually.

TABLE XXII

SUMMARY OF EXPERIMENTAL DATA FOR STUDENTS IN ALGEBRA I

EQUATION SOLVING

Scores	Symbols	Total for Entire Sample
Gain in Algebra I	ΣY^2	15,014
Henmon Nelson I.Q. Scores	ΣX_1^2	1,039.231
Orelans Prognosis Test For Algebra I	ΣX_2^2	360,364
Crossproducts	$\Sigma X_1 Y$	123,388
	$\Sigma X_2 Y$	71,854
	$\Sigma X_1 X_2$	603,470

Table XXIII illustrates the data obtained from the test on equation solving in deviation form. The values in Table XXI and Table XXII were used to compute the sums of squares and the sums of crossproducts in deviation form for the total sample and for within subgroups.

TABLE XXIII

SUMS OF SQUARES AND CROSSPRODUCTS IN DEVIATION FORM FOR BOTH SUBGROUPS EQUATION SOLVING

Source of Variation	Σy^2	Σx_1^2	Σx_2^2	$\Sigma x_1 y$	$\Sigma x_2 y$	$\Sigma x_1 x_2$
Total	346.1428	6,264.035	13,221.1428	296.9285	496.8571	4,648.5715
Within Subgroups	279.6429	1,769.8215	13,091.9286	277.5715	584.2858	4,696.1429

Table XXIV demonstrates the test for significance in achievement in the solving of equations after the regression equations have been calculated and adjustments have been made in the sum of squares. A test of significance was made of the null hypothesis that there was not a significant difference in the ability to solve algebraic equations at the end of the instructional period. The analysis of covariance is demonstrated in Table XXIV. The *F*-value of 24.73 with two and seventy nine degrees of freedom is significant beyond the .01 level of confidence. The null hypothesis was rejected. Therefore, when the criterion means of the three groups were adjusted for individual differences in I.Q. and scores on the Orleans Prognosis Test, the difference was so large that it was not caused by a sampling accident. Presumably the difference in the ability of students to solve equations was caused by the teaching procedures.

TABLE XXIV

TEST OF SIGNIFICANCE OF INFLUENCE OF TEACHING METHOD ON ACHIEVEMENT IN ALGEBRA I EQUATION SOLVING

		Residuals	
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	81	324.2128	
Within Subgroups	79	199.3755	2.5237
Difference	2	124.8373	62.4186

$F = 24.73, \; p < .01$

Table XXV demonstrates the t test for significance of differences among mean scores derived from tests on equation solving after the criterion means have been adjusted for differences that cannot be attributed to the teaching method. To have a significant difference at the .05 level of confidence a differential of at least .86 is required. A differential of 1.13 must be obtained at the .01 level for the difference to be significant.

TABLE XXV

SIGNIFICANCE OF DIFFERENCES AMONG ADJUSTED Y MEANS

$$S.D._{y.x} = \sqrt{2.5237} = 1.60$$

$$S.E._{m.\,y.x.} = \frac{1.60}{\sqrt{28}} = 1.6 =$$

$S\,E_d$ between any two adjusted means $= 1.6 \sqrt{\frac{1}{28} + \frac{1}{28}}$

$$= 1.6 \times .2672 = .43$$

For df = 79, $t_{.05} = 1.99$; $t_{.01} = 2.63$

Significant difference at the .05 level = 1.99 X .42 = .86

Significant difference at the .01 level = 2.63 X .43 = 1.13

Table XXVI gives the significance of the differences between the adjusted group means. There was not a significant difference between the two groups using conventional teaching procedures. There was a significant difference between Group B and Group A at the .05 level of confidence. There was a significant difference between Group C and Group A at the .01 level of confidence. The groups using conventional teaching procedures experienced achievement in equation solving that was significantly greater than that of the group using the program.

TABLE XXVI

SIGNIFICNACE OF ACHIEVEMENT AMONG GROUPS IN THE SOLUTION OF ALGEBRAIC EQUATIONS

Group	Adjusted Mean	$\overline{Yc} - \overline{Yb}$	$\overline{Yc} - \overline{Ya}$	$\overline{Yb} - \overline{Ya}$
C	14.09	.85		
B	13.24			.94*
A	12.30		1.79**	

* Indicates significance at the .05 level

** Indicates significance at the .01 level

Hypothesis 6. There will be a significant difference in the ability to represent relationships algebraically and to set up equations for given problems.

Table XXVII gives a summary of the data obtained from the test on representing relationships algebraically and in the formation of equations. The criterion used was the first semester gain scores as measured by the Seattle Algebra Test on Ability to represent relationships algebraically and to formulate equations. The academic ability and the mathematical ability could conceivably influence each student's response to the criterion, these individual differences were controlled by the Henmon Nelson I.Q. scores as a measure of academic ability and the scores on the Orleans Prognosis Test as a measure of mathematical ability. Using these scores as control variables in the analysis of covariance, the possible bias introduced by individual differences was removed in so far as those factors adequately represent the differences in question. The information in Table XXVII indicates that each group experienced a gain in achievement. Group A, using programmed materials, had the lowest mean gain score of the three groups.

TABLE XXVII

SUMS AND MEANS OF THE CRITERION AND CONTROL VARIABLES FOR ALGEBRA I STUDENTS TESTING THE ABILITY TO REPRESENT RELATIONSHIPS ALGEBRAICALLY AND TO SET UP EQUATIONS

	Number	Gain in Achievement		I.Q.		Orleans Prognosis	
	N	ΣY	$\bar{Y}$	ΣX_1	$\bar{X}_1$	ΣX_2	$\bar{X}_2$
Group A	28	333	11.89	3108	111	1833	65.46
Group B	28	367	13.11	3127	111.68	1752	62.57
Group C	28	342	12.21	3080	110	1815	64.82
	84	1042	12.40	9315	110.89	5400	64.29

Table XXVIII gives a summary of the data obtained from the test on algebraic relationships and equation formation. The sums of squares and the sum of all possible crossproducts are necessary for the computation and are shown in the following table. These values were found for the entire sample and not for the three groups individually.

TABLE XXVIII

SUMMARY OF EXPERIMENTAL DATA FOR STUDENTS IN ALGEBRA I CONSIDERING THE ABILITY TO REPRESENT RELATIONSHIPS ALGEBRAICALLY AND IN THE FORMATION OF EQUATIONS

Scores	Symbols	For Entire Sample
Scores in Algebra I	ΣY^2	13,166
Henmon Nelson I.Q. Scores	ΣX_1^2	1,039,231
Orleans Prognosis Test for Algebra I	ΣX_2^2	360,364
Crossproducts	$\Sigma X_1 Y$	115,680
	$\Sigma X_2 Y$	67,193
	$\Sigma X_1 X_2$	603,470

Table XXIX demonstrates the data obtained from the test on algebraic relationships and equation formation in deviation form. The values in Table XXVII and Table XXVIII were used to compute the sums of squares and the sums of crossproducts in deviation form for the total sample and for within subgroups.

TABLE XXIX

SUMS OF SQUARES AND CROSSPRODUCTS IN DEVIATION FORM

FOR BOTH SUBGROUPS

Source of Variation	Σy^2	Σx_1^2	Σx_2^2	$\Sigma x_1 y$	$\Sigma x_2 y$	$\Sigma x_1 x_2$
Total	240.2380	6,264.035	13,221.1428	129.6428	207.2857	4,648.5715
Within Subgroups	218.0715	1,769.8215	13,091.9286	110.9643	260.7500	4,696.1429

Table XXX demonstrates the test for significance in achievement in algebraic relationships and equation formation after the regression equations have been calculated and adjustments have been made in the sum of squares. A test of significance was made of the null hypothesis that there was not a significant difference in the ability to represent relationships algebraically and to set up equations to solve problems at the end of the instructional period. The analysis of covariance is shown in Table XXX. The F-value of 5.09 with two and seventy nine degrees of freedom is significant beyond the .01 level of confidence. Therefore, when the criterion means of the three groups were adjusted for individual differences in I.Q. and scores on the Orleans Prognosis Test, the difference was so large that it was not caused by a sampling accident. The difference in achievement can be attributed to the influence of the teaching procedures.

TABLE XXX

TEST OF SIGNIFICANCE OF INFLUENCE OF TEACHING METHOD ON ACHIEVEMENT IN ALGEBRAIC RELATIONSHIPS AND EQUATION FORMATION

		Residuals	
Source of Variation		Sum of Squares	Mean Square
Total	81	236.2922	
Within Subgroups	79	209.3154	2.6496
Difference	2	26.9768	13.4884

$F = 5.09,\ p < .01$

Table XXXI demonstrates the t test for significance of differences among means after the criterion means have been adjusted for differences that cannot be attributed to the teaching procedure. To have a significant difference at the .05 level of confidence it was necessary to have a differential of at least .88. A differential of 1.16 must be reached at the .01 level to have a significant difference.

TABLE XXXI

SIGNIFICANCE OF DIFFERENCES AMONG ADJUSTED Y MEANS

$$S.D._{y.x} = \sqrt{2.6496} = 1.63$$

$$S.E.M._{y.x} = \frac{1.63}{\sqrt{28}} = \frac{1.63}{5.292} = .308$$

$$S\,E_d \text{ between any two adjusted means} = 1.63\sqrt{\frac{1}{28} + \frac{1}{28}}$$

$$= 1.63 \times .2672 = .44$$

For df = 79, t .05 = 1.99; t .01 = 2.63

Significant difference at the .05 level = 1.99 X .44 = .88

Significant difference at the .01 level = 2.63 X .44 = 1.16

Table XXXII illustrates the significance of the differences between adjusted group means. There was not a significant difference between the two groups using conventional teaching procedures. Group B, a conventional group, differed significantly from the group using the programmed materials at the .05 level of confidence. There was not a significant difference between Group C, a conventional group, and Group A.

TABLE XXXII

SIGNIFICANCE OF ACHIEVEMENT AMONG GROUPS IN THE ABILITY TO REPRESENT RELATIONSHIPS ALGEBRAICALLY AND TO SET UP EQUATIONS

Group	Adjusted Mean	$\bar{Y}b - \bar{Y}c$	$\bar{Y}b - \bar{Y}a$	$\bar{Y}c - \bar{Y}a$
B	12.86	.44		
C	12.42			.49
A	11.93		.93*	

* Indicates significance at the .05 level

Hypothesis 7. There will be a significant difference in the choice of teaching methods in the experimental class at the end of the instructional period.

Table XXXIII provides the data concerning the choice of method in the class using programmed materials. At the end of the instructional period the students were given an opportunity to make a choice relative to the teaching procedure they would prefer for the second semester. Nineteen students made the choice to continue the use of programmed materials. Nine students indicated that they would prefer a change to conventional procedures of instruction. Chi Square was the statistical method used to determine the significance of the student's preference. The Chi Square value of 3.571 was not significant at the .05 level of confidence. The null hypothesis was not rejected. It cannot be presumed that the teaching procedures influenced the choice of students.

XXXIII

CHOICE OF PROGRAM OR CONVENTIONAL TEACHING METHODS IN GROUP A

	Do Not Prefer Change Favorable	Prefer Change Unfavorable
Group A	19 fe = 14	9 fe = 14

χ^2 = 3.571, p. .05

SUMMARY

Seven hypotheses were stated for this study. On the basis of the results obtained from the statistical analyses, the null hypotheses were rejected or not rejected at the .05 level of confidence. The single classification analysis of covariance as developed by James E. Wert in his book <u>Statistical Methods in Educational and Psychological Research</u> was used to determine the significance of achievement in Algebra I when different teaching methods were utilized, and allowances were made for differences in ability that was found in each group. The t test as developed by Henry E. Garrett in his text <u>Statistics in Psychology and Education</u> was used to determine the significance of the difference in the adjusted mean scores.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Review of the Study

The major objective of this study was to compare achievement in Algebra I when different teaching methods were used. The minor objective was to determine if there was a significant change in attitude toward mathematics due to methods of instruction. The study was limited to one school and a small population. Inferences are limited to the population that was sampled.

Conclusion of the Study

On the basis of this research and subject to the specified limitations, the following conclusions were made:

1. Students in all groups achieved in Algebra I. A significant $\underline{F}$ value was found on the test of significance of influence of the teaching method on achievement. Therefore, the difference in achievement can be presumed to be the result of the teaching method and not the result of I.Q. or the Orleans Prognosis Test. In the test for significance of differences among adjusted means, it was concluded that groups B and C differed significantly from group A at the .01 level and that group C had a significant difference from group B at the .01 level. The groups taught by the conventional method of instruction experienced achievement that was significantly greater

than that of the group that used programmed materials. The null hypothesis was rejected.

2. The null hypothesis was not rejected when the test for significance of the difference in favorable attitudes toward mathematics was made. In the group using the program the attitude of twenty students changed to unfavorable while eight changes were favorable. In the conventional classes there were twenty-seven unfavorable changes compared to twenty-nine favorable changes. The assumption cannot be made that the attitude change was the result of the teaching methods.

3. The null hypothesis was rejected when the F test was made for significance of influence of the teaching method in algebraic vocabulary. Achievement can be presumed to be due to the teaching method. The t test was applied to the adjusted means. Group B differed significantly from Group A and C at the .01 level. There was not a significant difference between Group A and C. Group B taught by conventional instructional methods, had a significant gain in achievement over the programmed group and the other group taught by conventional methods.

4. Student achievement in the fundamental processes of algebra can be attributed to the teaching method. A significant F was computed, and the null hypothesis was rejected. The t test for significance of the difference among adjusted means provides a basis to assume that the gain experienced by the conventional classes over the programmed class was significant at the .05 level. There was not a significant difference between the classes taught by conventional methods.

5. The $\underline{F}$ value was significant beyond the .05 level of confidence when statistical methods were applied to the data obtained from the test for achievement in equation solving. When the criterion means of the group were adjusted for individual differences in I.Q. and on scores made on the Orleans Test, the difference can be presumed to be due to the teaching methods. The null hypothesis was rejected. The conventional groups experienced better mean achievement scores than the group using the program. The difference was significant at the .05 level. There was not a significant difference between the conventional groups.

6. Teaching procedures had a significant influence on achievement in equation formation and in the understanding of algebraic relationships. The $\underline{F}$ value was significant beyond the .05 level of confidence and the null hypothesis was rejected. The conventional groups had greater mean gain scores than the group using programmed materials. However, only one of the conventional groups had a gain that was significant at the .05 level of confidence when compared with the experimental group.

7. At the end of the first semester nine students in the group using the program made a preference to change to conventional methods of instruction. Nineteen preferred to continue to use the program materials. The null hypothesis was not rejected. We cannot presume that the students preferred one method of instruction over the other.

Summary

It was found in the study that the teaching methods had a significant influence on achievement in first-year algebra. The results from the study indicate that the classes using conventional methods of instruction achieved at a significantly higher level than the class using program materials. There was not a significant change in the attitudes of students toward mathematics due to methods of instruction. The method of instruction did not have a significant influence in determining the teaching method that students preferred.

Recommendations

The writer makes the following recommendations as the result of this study:

1. More studies should be conducted comparing achievement when different methods of instruction are used.

2. More studies should be conducted to determine the significant factors that influence students' attitudes toward teaching methods and subject matter.

3. Additional studies should be made to determine what are the best ways to use program materials.

4. More research is needed to determine at what grade levels can programmed materials be used to the best advantage for students and teachers.

5. Research should be conducted to determine more adequately the type of student that can use a program to the best advantage.

6. More programs using the modern concepts of algebra should be developed.

7. Teachers and school administrators should continued to evaluate program materials and to experiment with their use to determine their proper place in the instructional program.

BIBLIOGRAPHY

(1) Banta, T. J. "Attitudes Toward a Programmed Text: The Analysis of Behavior Compared With a Textbook of Psychology" Audio Visual Communications Review, XI (November 1963), 227-240.

(2) Belton, J. R. "Teaching Machines and Programmed Learning in the Classroom" National Elementary Principal, XLII (February 1963), 28-31.

(3) Blackman, L. S. "Teaching Machines and the Mentally Retarded" School Life, XLVI (November 1963), 10-12.

(4) Boehm, G. A. W. "Can People Be Taught Like Pigeons? Programmed Teaching" Fortune, LXII (October 1960), 176-179.

(5) Boroff, D. "Education Comes of Age" Parents Magazine, XXXVIII (February 1963), 74-76.

(6) Bossone, R. M. "Programmed Materials: A Teaching Aid" Clearing House, XXXVIII (November 1963), 148-151

(7) Boutwell, W. D. "Whats Happening in Education? Programmed Instruction" PTA Magazine, LVIII (October 1963), 22.

(8) Buckley, N. "Programmed Learning: Return to Reality" Duns Review and Modern Industry, LXXXIII (May 1964), 46-47.

(9) Caulfield, R. L. "Evaluation of Programmed Texts" School and Society, XCI (March 1963), 116-117.

(10) Clark, J. F. "Programmed Learning: My First Six Months" Mathematics Teacher LV (November 1962), 579-581.

(11) Cronback, J. L. "What Research Says About Programmed Instruction" NEA Journal, LI (December 1962), 45-47.

(12) Dessart, D. J. "Some Thoughts on Programmed Instruction in Mathematics" School Science and Mathematics, LXIV (April 1964), 285-288.

(13) Edling, Jack V. et al. Four Case Studies of Programmed Instruction, New York: Fund for the Advancement of Education, 1964.

(14) Feldhusen, J. F. "Study of Nine Methods of Presentation of Programmed Learning Material" Journal Educational Research, LV (January 1962), 491-496.

(15) ______. "Teacher vs. Programmed Learning" Wisconsin Journal of Education, XCV (November 1962), 8-10.

(16) ______. "Taps for Teaching Machines" Phi Delta Kappan, LXIV (March 1963), 265-267.

(17) Forbes, J. E. "Programmed Instructional Materials: Past, Present, and Future" Mathematics Teacher, LVI (April 1963), 224-227.

(18) Gagne, R. M. "Learning and Proficiency in Mathematics" Mathematics Teacher, LVI (December 1963), 620-626.

(19) Garrett, Henry E. Statistics in Psychology and Education, New York: McKay, 1958.

(20) Geis, G. L. "Some Considerations in the Evaluation of Programs" Audio Visual Communications Review, X (January 1962), 64-69.

(21) Geller, M. S. "Pupils Attitudes Toward Programmed Learning" Science Teacher, XXX (March 1963), 265-267.

(22) Goldberg, M. H. "Comparison of Programmed and Conventional Instruction Methods" Journal Applied Psychology, XLVIII (April 1964), 110-114.

(23) Hart, Walter W. A First Course in Algebra, Boston: D. C. Heath and Company, 1947.

(24) Hecinger, F. M. "Big Changes Coming in Education" Parents Magazine, XXXV (September 1960), 46-49

(25) Heimer, Ralph T. "Some Implications of Programmed Instruction for the Teaching of Mathematics" Mathematics Teacher, LIV (May 1961) 333-335.

(26) Helen, H. A. "Programmed Materials Today" Critique and Proposed" Elementary School Journal, LXIII (January 1963), 189-196.

(27) Hester, F. "Programmed Learning Can Better Teacher-Pupil Relationship" Grade Teacher, LXXIX (May 1962), 54.

(28) Hilgard, E. R. Conditioning and Learning, New York: Appleton, Century, Crofts Inc., 1940.

(29) Horton, L. W. "New Mathematics and Programmed Learning: What the Roanoke Teachers are Saying" Audio Visual Instructor, (March 1962), 333-335.

(30) Jovanovich, W. "When Publishers Go Public" Saturday Review, XLVII (May 1964), 21-22.

(31) Lambert, P. "Experimental Folklore and Experimentation the Study of Programmed Learning in the Wauwatosa Public Schools" Journal Education Research, LV (July 1962), 485-494.

(32) Lange, Phil C. "Selection and Use of Programmed Learning Materials" NEA Journal, (April 1964), 28-29.

(33) Lunsdaine, A. A. and Glaser, Robert. Teaching Machines and Programmed Learning, Washington: Department of Audio-Visual Instruction National Education Association. 1960.

(34) Lunsdaine, A. A. "Some Critical Issues in the Employment of Instruction Through Programmed Learning" Audio Visual Communication Review, X (January 1962), 61-64.

(35) ________. "Criteria for Evaluating Self-Instructional Programs" School Life, XLV (November 1962), 14-17.

(36) McGarvey, Paul "Programmed Instruction in Ninth Grade Algebra: Mathematics Teacher, LV (November 1962), 576-579.

(37) Maier, M. H., and Jacobs, P. I. "Programmed Learning Some Recommendations and Results" National Association of Secondary School Principals Bulletin, XLVIII (April 1964), 242-255.

(38) Margolis, R. J. "Do Teaching Machines Really Teach?" Redbook, CXXI (September 1963), 51 +.

(39) Moore, J. W., and Smith, W. J. "Motivation in Automated Instruction" School Life, XLVI (November 1963), 21-22.

(40) Murphy, J. R., and Goldberg, I. A. "Strategies for Using Programmed Instruction" Howard Business Review, XLII (May 1964), 115-132.

(41) Nasca, Don. "Have You Tried a Program Yet?" Science Education, XLVII (February 1963), 68-72.

(42) Ohles, J. F. "Approach to Machine Teaching" School and Society, LXXXVIII (November 1960), 440-441.

(43) Packer, R. E. "Tomorrow Automated Schools" Science Digest, LIII (May 1963), 34-38.

(44) Pressey, S. L. "Puncture of the Huge Programming Boom?" Education Digest, XXIX (April 1964), 9-12. Teachers College Record, New York: Columbia University.

(45) Probst, G. E. "Programmed Learning in the Schools: Tasks for 1962" Science Teacher, XXIX (October 1962), 34-35.

(46) Randolph, P. H. "Experiment in Programmed Instruction in Junior High School" Mathematics Teacher, LVII (March 1964), 160-162.

(47) Silberman, H. F. "Self Teaching Devices and Programmed Materials: Comparisons with Conventional Instruction" Review of Educational Research, XXXII (April 1962), 185-186.

(48) Smith, M. D. "Some Considerations in Teaching Mathematics by Programmed Insturction" Mathematics Teacher, LV (May 1962), 343-350.

(49) Stalurow, L. M. "Problems in Evaluating Automated Instruction" Teacher College Record, LXIII (October 1961), 66-70.

(50) ______. "Problems, Procedures, Pitfalls and Promise of Programming Practice" National Association of Secondary School Principals Bulletin, (April 1964), 256-270.

(51) Talley, C. A., Jr. "Programmed Instruction Solves Problems" Texas Outlook, XLVIII (May 1964), 22-23.

(52) Teaching With Temac, Chicago: Encyclopaedia Britannica Press, Inc., n.d.

(53) Temac Case History Report, Wilmette: Encyclopaedia Britannica Films, Inc., (June 1964).

(54) The Use of Programmed Instruction in U. S. Schools, Washington: The Center for Programmed Instruction, Inc., United States Government Printing Office, 1963.

(55) Tracey, W. R. "Programming: Evaluating Achievements" Clearing House, XXXVIII (November 1963) 1943-148.

(56) Watson, Goodwin "What Do We Know About Learning" NEA Journal, (March 1963), 20-22.

(57) Wert, James E., Neidt, Charles O., and Ahmann, J. Stanley. Statistical Methods in Educational and Psychological Research, New York: Appleton, Century, Crofts Inc., 1954.

(58) Ziskind, M. "Programmed Instruction for Curriculum Enrichment" National Catholic Education Association Bulletin, LX (August 1963), 100-102.

APPENDIX A

Form AM Seattle Algebra Test

EVALUATION AND ADJUSTMENT SERIES

GENERAL EDITOR: WALTER N. DUROST, SCHOOL OF EDUCATION, BOSTON UNIVERSITY

SEATTLE ALGEBRA TEST

For End of First Half Year

BY HAROLD B. JEFFERY, EARL E. KIRSCHNER, PHILLIP STUCKY,
JOHN R. RUSHING, OTIE P. VAN ORSDALL, DAVID SCOTT
SEATTLE PUBLIC SCHOOLS

FORM AM

DIRECTIONS:

Do not open this booklet until you are told to do so.

This is a test of your knowledge of algebra. For each question there are five possible answers. You are to read each question and determine which answer is correct; then record the answer on the answer sheet. You may answer a question even when you are not perfectly sure that your answer is correct, but you should avoid wild guessing. Do not spend too much time on any one question.

Study the sample questions below, and notice how the answers are to be marked on the separate answer sheet.

Sample A. $2 + 3$ equals
- a. 9
- b. 8
- c. 6
- d. 5
- e. none of the above

For Sample A the answer, of course, is "5," which is answer d. Now look at your answer sheet. At the top of the page in the left-hand column is a box marked SAMPLES. In the five answer spaces after Sample A, a heavy mark has been made filling the space (the pair of dotted lines) marked d.

Sample B. If $5x = 15$, then x equals
- f. 75
- g. 20
- h. 3
- i. -3
- j. none of the above

The correct answer for Sample B is "3," which is answer h; so you would answer Sample B by making a heavy black mark that fills the space under the letter h. Do this now. If the correct answer had not been given, you would have chosen answer j, "none of the above."

Read each question carefully and decide which one of the answers is best. Notice what letter your choice is. Then, on the separate answer sheet, make a heavy black mark in the space under that letter. In marking your answers, always be sure that the question number in the test booklet is the same as the question number on the answer sheet. Erase completely any answer you wish to change, and be careful not to make stray marks of any kind on your answer sheet or on your test booklet. When you finish a page, go on to the next page. If you finish the entire test before the time is up, go back and check your answers. Work as rapidly and as accurately as you can.

When you are told to do so, open your booklet to page 2 and begin. The working time for this test is 40 minutes.

Published by World Book Company, Yonkers-on-Hudson, New York, and Chicago, Illinois

PRINTED IN U.S.A. SAT: AM-9

Part A. Vocabulary

1. In $3a^2c$, the c is
   1. a term.
   2. a binomial.
   3. an exponent.
   4. a factor.
   5. a numerical coefficient.

2. Which expression is a binomial?
   6. $3y$
   7. $5x + 10$
   8. $3(x-2) + 5y - 2z$
   9. a^2
   10. none of the above

3. In $6a^2m + 3y$, the 6 and 3 are
   1. terms.
   2. exponents.
   3. binomials.
   4. coefficients.
   5. literal factors.

4. In the algebraic expression $7a^2$, the ^{2} is
   6. a coefficient.
   7. a subtrahend.
   8. a binomial.
   9. a monomial.
   10. an exponent.

5. In $3x - 5y$, $3x$ is a
   1. factor.
   2. term.
   3. coefficient.
   4. binomial.
   5. root.

6. The fraction $\frac{7y}{5x}$ expresses
   6. an equation.
   7. a product.
   8. a sum.
   9. a quotient.
   10. a difference.

7. In the equation $x + 2 = 5$, 3 is
   1. a root.
   2. a factor.
   3. the left member.
   4. a literal term.
   5. the degree.

8. The expression $I = prt$ is called
   6. a binomial.
   7. a formula.
   8. a root.
   9. a trinomial.
   10. none of the above.

9. In the formula $d = rt$, the rate (r) may be expressed in
   1. miles.
   2. hours.
   3. miles per hour.
   4. hours per mile.
   5. none of the above.

Part B. Fundamental Processes

10. $(-2)(-2)(-2)$ equals
    a. -8
    b. -6
    c. $+6$
    d. $+8$
    e. none of the above

11. $8 + 2 \times 3 - 8 \div 2$ equals
    f. 11
    g. 10
    h. 3
    i. -3
    j. none of the above

12. $3x + 4x$ equals
    a. $7x$
    b. $7x^2$
    c. $12x$
    d. $12x^2$
    e. none of the above

13. $3a + 4b$ equals
    f. $12ab$
    g. $7ab$
    h. $3a + 4b$
    i. $7(a + b)$
    j. none of the above

14. $(5a^3)(-a)$ equals
    a. $4a^2$
    b. $5a^4$
    c. $5a^3 - a$
    d. $-5a^4$
    e. $-15a^4$

15. $15xy \div 5xy$ equals
    f. $10xy$
    g. $3xy$
    h. $-3xy$
    i. -3
    j. none of the above

16. $21 - (-5)$ equals
    a. -26
    b. -16
    c. 16
    d. 26
    e. none of the above

Go on to the next page.

17. $(-42) + (-6)$ equals
   - f. -48
   - g. -36
   - h. 36
   - i. 48
   - j. none of the above

18. $(32\,y^8) \div (-2\,y)$ equals
   - a. $30\,y^7$
   - b. $16\,y^8$
   - c. $-16\,y^7$
   - d. $-30\,y^7$
   - e. none of the above

19. 5^3 equals
   - f. 15
   - g. 25
   - h. 125
   - i. 625
   - j. none of the above

20. $(-3\,y^2)^3$ equals
   - a. $27\,y^6$
   - b. $-27\,y^5$
   - c. $-3\,y^6$
   - d. $-27\,y^6$
   - e. none of the above

21. $5(a - 2) - 4\,a$ equals
   - f. $-15\,a - 10$
   - g. $a - 2$
   - h. $9\,a - 10$
   - i. $a - 10$
   - j. none of the above

22. $42\,y - [10 - 2(3\,y - 4) - 2]$ equals
   - a. $48\,y + 16$
   - b. $48\,y - 16$
   - c. $36\,y - 20$
   - d. $36\,y - 16$
   - e. $18\,y + 30$

23. $\dfrac{-24\,n^4 - 8\,n^3 + 16\,n^2}{-8\,n^2}$ equals
   - f. $3\,n^2 + n - 2$
   - g. $3\,n^2 - n - 2$
   - h. $-3\,n^2 - n + 2$
   - i. $3\,n^2 - 1\,n - 2$
   - j. none of the above

24. $5\,W + 2\,L - W - 8\,L$ equals
   - a. $4\,W + 6\,L$
   - b. $4\,W - 10\,L$
   - c. $6\,W - 6\,L$
   - d. $-4\,W - 6\,L$
   - e. none of the above

25. If $a = 3$ and $b = 2$, then $6\,a^2 - 2\,ab + 3\,b^2$ equals
   - f. 36
   - g. 54
   - h. 78
   - i. 324
   - j. 348

26. In the formula $A = LW - 3\,S^2$, find A if $L = 16$, $W = 5$, and $S = 4$.
   - a. 224
   - b. 122
   - c. 78
   - d. -64
   - e. none of the above

27. If $a = 2$, $b = -3$, then $2\,a(a + 2\,b)$ equals
   - f. 32
   - g. $+16$
   - h. -16
   - i. -48
   - j. none of the above

28. In the temperature formula, $C = \frac{5}{9}(F - 32°)$, find C if $F = 50°$.
   - a. $45\frac{5}{9}°$
   - b. $18°$
   - c. $10°$
   - d. $-10°$
   - e. none of the above

29. From $-19\,a + 5\,b - 10\,c$ take $-9\,a + 10\,b - 3\,c$.
   - f. $-10\,a - 5\,b - 7\,c$
   - g. $10\,a + 15\,b + 13\,c$
   - h. $-28\,a + 15\,b - 13\,c$
   - i. $-10\,a + 15\,b - 7\,c$
   - j. none of the above

30. $(3\,x + 2)(x - 1)$ equals
   - a. $3\,x^2 - 5\,x - 2$
   - b. $3\,x^2 + 5\,x - 2$
   - c. $4\,x + 1$
   - d. $3\,x^2 - x - 2$
   - e. $3\,x^2 - 2$

Part C. Equations

31. If $\frac{x}{2} = 6$, then x equals
   - a. 3
   - b. 4
   - c. 8
   - d. 12
   - e. none of the above

32. If $5 = 2 + t$, then t equals
   - f. -3
   - g. $\frac{2}{5}$
   - h. 3
   - i. 10
   - j. none of the above

Go on to the next page.

33. If $3c + 12 = 6$, then c equals
   - a. 6
   - b. 2
   - c. -2
   - d. -6
   - e. none of the above

34. If $\frac{2}{3}x = 2$, then x equals
   - f. 3
   - g. $\frac{4}{3}$
   - h. 1
   - i. $-\frac{1}{2}$
   - j. none of the above

35. If $6 + 3x = x - 4$, then x equals
   - a. 5
   - b. $2\frac{1}{2}$
   - c. 1
   - d. $-2\frac{1}{2}$
   - e. none of the above

36. If $3s - 1 = 2(s + 3)$, then s equals
   - f. -7
   - g. 1
   - h. $\frac{7}{5}$
   - i. 4
   - j. 7

37. If $\frac{3}{2}x + 5 = x + 8$, then x equals
   - a. 6
   - b. $1\frac{1}{2}$
   - c. $\frac{6}{5}$
   - d. $-\frac{6}{5}$
   - e. -6

38. If $\frac{x}{3} - \frac{x}{9} = 6$, then x equals
   - f. 27
   - g. 18
   - h. 3
   - i. 0
   - j. none of the above

39. The value of x which satisfies both of the equations $\begin{Bmatrix} 3x + 2y = -2 \\ 2x + 2y = -4 \end{Bmatrix}$ is
   - a. -6
   - b. -2
   - c. 2
   - d. 6
   - e. none of the above

Part D. Algebraic Representation and Problems

DIRECTIONS. *In the following questions, read each problem and decide which of the five given algebraic expressions or equations is correct. DO NOT SOLVE THE EQUATIONS.*

40. If n represents an odd number, the next higher consecutive odd number is
   - a. $2n$
   - b. $n + 1$
   - c. $n + 2$
   - d. $n + 3$
   - e. n^2

41. The area of a rectangle whose length is L and whose width is W is
   - f. $L + W$
   - g. $2LW$
   - h. $2L + 2W$
   - i. LW
   - j. $(LW)^2$

42. A line 6 inches long is divided into two parts. If the shorter part is S inches, the longer part is
   - a. $S - 6$ inches.
   - b. $6 - S$ inches.
   - c. $\frac{6}{S}$ inches.
   - d. $S + 6$ inches.
   - e. none of the above.

43. One angle is three times a smaller angle. Their sum is 180°. Find the number of degrees in each angle. (Let a equal the number of degrees in the smaller angle.)
   - f. $a + 3 = 180°$
   - g. $3a = 180°$
   - h. $2a + 3 = 180°$
   - i. $a + 3a = 180°$
   - j. none of the above

44. Mr. Randall in Everett and Mr. Moore in Tacoma decide to hike toward each other until they meet. Everett is 60 miles from Tacoma. If Mr. Randall averages 3 miles per hour and Mr. Moore averages 4 miles per hour, in how many hours will they meet? (Let t equal the number of hours until they meet.)
   - a. $4t - 3t = 60$
   - b. $3t + 4t = 60$
   - c. $\frac{t}{4} + \frac{t}{3} = 60$
   - d. $\frac{t}{7} = 60$
   - e. none of the above

45. Helen's age is one third of her mother's age. The difference between their ages is 24 years. How old is each? (Let M equal the mother's age.)
   - f. $M - \frac{M}{3} = 24$
   - g. $3M = 24$
   - h. $\frac{1}{3}M = 24$
   - i. $M - \frac{1}{3} = 24$
   - j. none of the above

46. A picture is 4 inches longer than it is wide. If w is the width, the perimeter is
   - a. $P = 2(w + 4)$
   - b. $P = 2(2w + 4)$
   - c. $P = w(w + 4)$
   - d. $P = 2w + 4$
   - e. none of the above

47. The price of pork increased 10% in one month. If it now sells for 66 cents per lb., what was the price before the increase? (Let P equal the price before the increase.)
   - f. $P + 0.10 = 66$
   - g. $P + 0.1 = 66$
   - h. $P + 0.1P = 66$
   - i. $P - 0.1P = 66$
   - j. none of the above

Go back and check your answers.

APPENDIX B

Form BM Seattle Algebra Test

EVALUATION AND ADJUSTMENT SERIES

GENERAL EDITOR: WALTER N. DUROST, SCHOOL OF EDUCATION, BOSTON UNIVERSITY

SEATTLE ALGEBRA TEST

For End of First Half Year

BY HAROLD B. JEFFERY, EARL E. KIRSCHNER, PHILLIP STUCKY,
JOHN R. RUSHING, OTIE P. VAN ORSDALL, DAVID SCOTT
SEATTLE PUBLIC SCHOOLS

FORM **BM**

DIRECTIONS:

Do not open this booklet until you are told to do so.

This is a test of your knowledge of algebra. For each question there are five possible answers. You are to read each question and determine which answer is correct; then record the answer on the answer sheet. You may answer a question even when you are not perfectly sure that your answer is correct, but you should avoid wild guessing. Do not spend too much time on any one question.

Study the sample questions below, and notice how the answers are to be marked on the separate answer sheet.

Sample A. $2 + 3$ equals
- a. 9
- b. 8
- c. 6
- d. 5
- e. none of the above

For Sample A the answer, of course, is "5," which is answer d. Now look at your answer sheet. At the top of the page in the left-hand column is a box marked SAMPLES. In the five answer spaces after Sample A, a heavy mark has been made filling the space (the pair of dotted lines) marked d.

Sample B. If $5x = 15$, then x equals
- f. 75
- g. 20
- h. 3
- i. -3
- j. none of the above

The correct answer for Sample B is "3," which is answer h; so you would answer Sample B by making a heavy black mark that fills the space under the letter h. Do this now. If the correct answer had not been given, you would have chosen answer j, "none of the above."

Read each question carefully and decide which one of the answers is best. Notice what letter your choice is. Then, on the separate answer sheet, make a heavy black mark in the space under that letter. In marking your answers, always be sure that the question number in the test booklet is the same as the question number on the answer sheet. Erase completely any answer you wish to change, and be careful not to make stray marks of any kind on your answer sheet or on your test booklet. When you finish a page, go on to the next page. If you finish the entire test before the time is up, go back and check your answers. Work as rapidly and as accurately as you can.

When you are told to do so, open your booklet to page 2 and begin. The working time for this test is 40 minutes.

Published 1952 by World Book Company, Yonkers-on-Hudson, New York, and Chicago, Illinois

PRINTED IN U.S.A. SAT:BM-2

Part A. Vocabulary

1. In $7\ bx^2y$, the b is
   1. an exponent.
   2. a subtrahend.
   3. a factor.
   4. a term.
   5. none of the above.

2. In $2\ a^3$, the 2 is
   6. a polynomial.
   7. a literal factor.
   8. a term.
   9. a coefficient.
   10. none of the above.

3. The expression $x^2 + 3\ xy + b$, is
   1. a binomial.
   2. a term.
   3. a monomial.
   4. a polynomial.
   5. none of the above.

4. In the equation $x - 3 = 7$, 10 is
   6. a root.
   7. a check.
   8. the degree.
   9. a numerical factor.
   10. an identity.

5. In $5\ ay^2 + 3\ ax + 4\ ab$, the ^{2} is
   1. a polynomial.
   2. a factor.
   3. a coefficient.
   4. a monomial.
   5. none of the above.

6. In the expression $9\ b - 5\ x$, $5\ x$ is a
   6. factor.
   7. difference.
   8. sum.
   9. coefficient.
   10. literal term.

7. In the expression $(7)(4) = 28$, 28 is
   1. a quotient.
   2. a factor.
   3. an addend.
   4. a product.
   5. none of the above.

8. The expression $A = lw$ is called
   6. a binomial.
   7. a formula.
   8. a root.
   9. a trinomial.
   10. none of the above.

9. In the formula $I = prt$, the interest (I) may be expressed in
   1. per cent.
   2. rate.
   3. years.
   4. dollars.
   5. none of the above.

Part B. Fundamental Processes

10. $(-3)(-3)(-3)$ equals
   a. -27
   b. -9
   c. $+9$
   d. $+27$
   e. none of the above

11. $6 + 4 \div 2 - 3 \times 2$ equals
   f. 4
   g. 2
   h. 1
   i. -1
   j. none of the above

12. $4\ m + 7\ m$ equals
   a. $28\ m^2$
   b. $11\ m^2$
   c. $11\ m$
   d. $11(m + m)$
   e. none of the above

13. $5\ x + 3\ y$ equals
   f. $15\ xy$
   g. $8\ xy$
   h. $5\ x + 3\ y$
   i. $8(x + y)$
   j. none of the above

14. $(4\ b)(-3\ b^2)$ equals
   a. $-12\ b^3$
   b. $4\ b - 3\ b^2$
   c. b^2
   d. $12\ b^3$
   e. none of the above

15. $20\ cd \div 4\ cd$ equals
   f. $5\ cd^2$
   g. $5\ cd$
   h. -5
   i. 5
   j. none of the above

16. $7 - (-3)$ equals
   a. 21
   b. 10
   c. 4
   d. -10
   e. none of the above

Go on to the next page.

17. $(-12) + (-6)$ equals
    f. -18
    g. -2
    h. 18
    i. 72
    j. none of the above

18. $15\,x^5 \div (-3\,x)$ equals
    a. $-5\,x^3$
    b. $-5\,x^4$
    c. $-18\,x^6$
    d. $5\,x^3$
    e. none of the above

19. 3^3 equals
    f. 6
    g. 9
    h. 27
    i. 33
    j. none of the above

20. $(-2\,b^2)^3$ equals
    a. $8\,b^6$
    b. $-6\,b^5$
    c. $-8\,b^5$
    d. $-8\,b^6$
    e. none of the above

21. $5(2 - a) - 8$ equals
    f. $-5\,a - 30$
    g. $-a + 2$
    h. $-35\,a$
    i. $-5\,a - 50$
    j. none of the above

22. $3\,y - [7 - 2(3\,y - 5) - 4]$ equals
    a. $9\,y + 7$
    b. $9\,y - 13$
    c. $11\,y$
    d. $3\,y + 2$
    e. none of the above

23. $\dfrac{15\,a^4 - 10\,a^3 + 5\,a}{-5\,a}$ equals
    f. $-3\,a^3 + 2\,a^2 - 1$
    g. $3\,a^3 - 2\,a + a$
    h. $-3\,a^3 + 2\,a^2$
    i. $-3\,a^3 - 2\,a - 1$
    j. none of the above

24. $6\,h + 2\,w - h + 7\,w$ equals
    a. $14\,hw$
    b. $9\,w - 5\,h$
    c. $5\,h + 9\,w$
    d. $9\,h^2 + 5\,w^2$
    e. none of the above

25. If $x = 3$ and $y = 1$, then $4\,x^2 - 3\,xy + 2\,y^2$ equals
    f. 139
    g. $29\,xy$
    h. 29
    i. -29
    j. none of the above

26. In the formula $A = 2\,S^2 - LW$, find A if $S = 10$; $L = 4$, and $W = 2$.
    a. 392
    b. 208
    c. 192
    d. 32
    e. none of the above

27. If $a = 2$ and $b = -4$, then $3\,a(a + b)$ equals
    f. -48
    g. -12
    h. $+12$
    i. $+36$
    j. none of the above

28. In the temperature formula $C = \frac{5}{9}\,(F - 32°)$, find C if $F = 70°$.
    a. $56\frac{4}{9}°$
    b. $21\frac{1}{9}°$
    c. $20\frac{5}{9}°$
    d. $6\frac{8}{9}°$
    e. none of the above

29. $(-7\,x + 5\,y - z) - (-8\,x - 5\,y + z)$ equals
    f. $x - y + 2\,z$
    g. $x - 2\,z$
    h. $x + 10\,y - 2\,z$
    i. $-x$
    j. none of the above

30. $(2\,x - 3)(x + 1)$ equals
    a. $2\,x^2 - x - 3$
    b. $2\,x^2 - 3$
    c. $2\,x^2 - 5\,x + 3$
    d. $2\,x^2 - 5\,x - 3$
    e. none of the above

Part C. Equations

31. If $x + 3 = 15$, then x equals
    a. 3
    b. 12
    c. 18
    d. 45
    e. none of the above

32. If $5\,a = -30$, then a equals
    f. -150
    g. -35
    h. -25
    i. 6
    j. none of the above

Go on to the next page.

33. If $\frac{x}{5} = -16$, then x equals
   a. -80
   b. -21
   c. -11
   d. $-3\frac{1}{5}$
   e. none of the above

34. If $\frac{r}{3} - 2 = 1$, then r equals
   f. 9
   g. 7
   h. 6
   i. -6
   j. none of the above

35. If $3c - 2 = 10 - c$, then c equals
   a. $\frac{1}{2}$
   b. 2
   c. 3
   d. 8
   e. none of the above

36. If $2(w - 3) = 12$, then w equals
   f. 3
   g. $4\frac{1}{2}$
   h. $7\frac{1}{2}$
   i. 9
   j. none of the above

37. If $9 = 3x - 15$, then x equals
   a. -8
   b. -2
   c. 8
   d. 21
   e. none of the above

38. If $\frac{x}{2} - \frac{x}{8} = 9$, then x equals
   f. 54
   g. 24
   h. 3
   i. 0
   j. none of the above

39. The value of x which satisfies both the equations $\begin{Bmatrix} 3x + 2y = 7 \\ 5x - 2y = 9 \end{Bmatrix}$ is
   a. -2
   b. -1
   c. 1
   d. 2
   e. none of the above

Part D. Algebraic Representation and Problems

DIRECTIONS. *In the following questions, read each problem and decide which of the five given algebraic expressions or equations is correct. DO NOT SOLVE THE EQUATIONS.*

40. If n represents an even number, the next higher consecutive even number is
   a. $2n$ b. $n + 1$ c. $n + 2$
   d. $n + 3$ e. n^2

41. The perimeter of a rectangle W feet wide and L feet long is
   f. LW g. $L + W$ h. $2L + W$
   i. $2W + L$ j. $2W + 2L$

42. The difference between two numbers is 3. If the larger number is L, the smaller number is
   a. $3L$ b. $L - 3$ c. $3 - L$
   d. $L + 3$ e. $\frac{L}{3}$

43. The sum of three times a number and one fourth of the same number is 13. What is the number? (Let n equal the number.)
   f. $\frac{3n + n}{4} = 13$
   g. $3(n + \frac{1}{4}) = 13$
   h. $3n + \frac{1}{4} = 13$
   i. $3n + \frac{n}{4} = 13$
   j. none of the above

44. A rectangle is 3 feet longer than it is wide. If its perimeter is 26 feet, what are its dimensions? (Let w equal the width.)
   a. $4w + 6 = 26$
   b. $2w + 3 = 26$
   c. $w + 4w = 26$
   d. $4w + 3 = 26$
   e. none of the above

45. A pair of skates sells for 10% more than it did six months ago. The present selling price is \$2.20. What was the selling price six months ago? (Let x equal the selling price six months ago.)
   f. $0.1x = \$2.20$
   g. $x + 0.1x = \$2.20$
   h. $2x + 0.1 = \$2.20$
   i. $x - 0.1x = \$2.20$
   j. none of the above

46. The complement of an angle is twice the given angle. Find the number of degrees in each angle. (Let a equal the number of degrees in given angle.)
   a. $2a = 180 - a$
   b. $a + 2a = 180$
   c. $2a = 180$
   d. $a + 2a = 90$
   e. none of the above

47. Two trucks traveling in opposite directions pass each other in Capitol City. The northbound truck averages 25 miles per hour and the southbound truck averages 30 miles per hour. In how many hours will they be 200 miles apart? (Let t equal the number of hours.)
   f. $25t + 30t = 200$
   g. $25t + 200 = 30t$
   h. $5t = 200$
   i. $30(t + 10) = 200$
   j. none of the above

Go back and check your answers.

APPENDIX C

Attitude Scale Toward Mathematics

ATTITUDES SCALE TOWARD MATHEMATICS

	Weight	
1.	1.17	I think mathematics is an excellent subject, and it commands my highest loyalty and respect.
2.	5.01	I am neither for or against mathematics, but I do not believe that to require mathematics for graduation will do anyone any harm.
3.	7.95	I feel the good done by taking mathematics is not worth the time and energy spent on it.
4.	9.01	I regard mathematics as a written memorial to human ignorance.
5.	7.18	I believe that mathematics will lose ground as more elective subjects are added to the school program.
6.	3.21	I feel mathematics is trying to adjust itself to a world more and more concerned with social problems and deserves support.
7.	8.49	The material taught in mathematics is altogether too superficial to be of interest to me.
8.	.44	I feel mathematics is the greatest means for increasing the knowledge of the world.
9.	.94	I think mathematics is the most important influence in the development of critical thinking and good work habits.
10.	4.01	I believe that mathematics is necessary, but like all other school subjects it has its fault.
11.	10.09	I regard mathematics as a harmful subject, slowing a person's reading rate, and making a person hate school.
12.	8.01	Mathematics is too theoretical for me, and so I stay away from it.
13.	5.34	I believe in the good of mathematics, but I am not able to put it to much practical use so don't care for it.
14.	1.24	I believe that mathematics furnished the stimulus for the best scholarship of our school.
15.	6.28	I am not much against mathematics, but if I do not like the teacher I do not take the course.

	Weight	
16.	10.61	I regard mathematics as hopelessly tied up with old-fashioned ideas.
17.	2.45	I believe that mathematics forces me to stick to a job fairly well and has a consequent good influence on the work in other school subjects.
18.	4.75	I am interested only to the extent of taking mathematics courses occasionally.
19.	9.51	I feel mathematics is ridiculous for it does not help a person solve everyday problems.
20.	5.33	Sometimes I feel taking mathematics is worth while, and sometimes I doubt it.
21.	1.71	My ability in mathematics is the primary guiding influence in planning my school program and my life's work.
22.	3.78	I like the good feeling I get from working on mathematics, but I do not agree with the idea that it makes me better in other school subject.
23.	7.02	My attitude toward mathematics is one of neglect due to lack of respect.
24.	8.95	I believe mathematics is a pet subject of the teachers and the principal and does not have any appeal to students.
25.	4.84	I am sympathetic toward mathematics, but I do not encourage others to take it.
26.	9.55	I regard mathematics as a subject that should not be taught in high school.
27.	6.23	I know too little about mathematics to express an opinion.
28.	.60	I regard mathematics as the most important subject in school.
29.	7.51	I am slightly against mathematics and intend taking only a little of it.
30.	9.02	I do not think a man is honest in his thinking if he says he takes mathematics for any reason other than that he has to.
31.	3.78	There is much that is too hard in mathematics, but I feel it is so important that it is my duty to help others when they have trouble with it.

Weight

32. 2.29 I feel that mathematics helps make other subjects easier to understand.

33. 10.55 I think mathematics is without question stupid and futile.

34. 2.29 I feel the number of people who take mathematics is a good indication of how many people think straight.

35. 9.36 I feel that mathematics is petty, and interested in too many things of little importance.

36. 2.65 In mathematics I do very good work and express myself well.

37. 8.89 I believe mathematics is really not of much good depending for its influence upon teachers who keep insisting mathematics is useful.

38. 5.01 I intend taking mathematics myself, but I believe its influence is on the decline.

39. 9.76 It seems absurd to me for anyone to be interested in mathematics.

40. 6.98 My attitude toward mathematics is best described as indifference.

41. 3.00 I believe that anyone who will work at mathematics will appreciate it.

42. 8.69 Mathematics is dull and nothing much can be done about it.

43. 7.12 My attitude toward mathematics is I can take it or leave it, with a slight tendency to disfavor it.

44. 4.45 I have a casual interest in mathematics.

45. 10.84 I have nothing but contempt for mathematics.

VITA

Allen Maynard Robson

Candidate for the Degree of

Doctor of Education

Thesis: A COMPARATIVE STUDY OF THE TEACHING OF FIRST YEAR ALGEBRA

Major Field: Education Administration

Biographical:

Personal Data: Born in Yates Center, Kansas, October 8, 1914, the son of Alonzo and Fae Robson.

Education: Attended Washington grade school, Yates Center, Kansas; graduated from Pauls Valley, Oklahoma High School in 1933; received the Bachelor of Science Degree from Oklahoma Baptist University, Shawnee, Oklahoma, with a major in mathematics and a minor in physical education in August 1937; received the Master of Science Degree in Education from Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma in 1949; completed requirements for the degree of Doctor of Education in Education Administration-Secondary Education at the Oklahoma State University, Stillwater, Oklahoma, August 1965.

Professional experience: Mathematics teacher and athletic coach at Cherokee, Oklahoma High School, 1937-1939. Mathematics teacher and athletic coach at Fairview, Oklahoma High School, 1940-1941. Mathematics teacher and athletic coach at Wagoner, Oklahoma, High School, 1941-42. Entered the United States Navy in April, 1942. Served as physical fitness officer and mahtematics instructor at the Navy Electrical Training School, St. Louis, Missouri; Armed Guard Commander, in charge of navy gun and communications crews aboard merchant ships; Executive officer of an L.C.I.G.; discharged with the rank of lieutenant in October, 1945. Mathematics teacher and athletic coach at Ponca City East Junior High School 1945-46. Mathematics teacher and athletic coach at Ponca City Senior High School 1947-1950. Director of Special Services for the Ponca City Board of

Education and Ponca City Senior High School athletic coach 1950-1960. Principal of Ponca City West Junior High School 1961-1965. Superintendent of Ponca City Public School System June 7, 1965.

Professional Organizations: National Education Association, National Association of Secondary School Principals, Oklahoma Education Association, Oklahoma Association of Secondary School Principals, Phi Delta Kappa.