PROGRAMMED INSTRUCTION IN BASIC MATHEMATICS AT CHRISTIAN COUNTY HIGH SCHOOL

RUSSELL DOUGLAS WEATHERWAX

PROGRAMMED INSTRUCTION IN BASIC MATHEMATICS AT CHRISTIAN COUNTY HIGH SCHOOL

An Abstract

Presented to

the Committee on Graduate Studies

Austin Peay State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in Education

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by

Russell Douglas Weatherwax

August, 1967

AN ABSTRACT

Statement of the Problem

The purpose of this study was to ascertain the effect, if any, of programmed instruction upon the achievement of the students in Advanced General Mathematics at Christian County High School in Hopkinsville, Kentucky.

Delimitation

This study was limited to forty-four students enrolled in Advanced General Mathematics at Christian County High School in Hopkinsville, Kentucky. The students were limited to the use of the text Basic Mathematics by Encyclopedia Britannica Press or the text New Applied Mathematics by Prentice-Hall.

Major Hypotheses

The major hypotheses are: The achievement of the students being taught by programmed instruction is significantly higher than that of the students being taught by the traditional methods of instruction. The decrease of retention in the students using programmed instruction is significantly less than that of the students being taught by traditional methods of instruction.

Methods and Procedures

Methods and procedures used in the collection of data

were literary research and statistical tabulation and analysis. Scores for the statistical analysis were obtained from the control group and the experimental group using the Madden-Peak Arithmetic Computation Form BM or AM in three testing periods.

Findings

In the group using programmed instruction there was a gain in achievement, but the gain was not significantly greater than that of the group being taught by the traditional methods of instruction. The decrease in retention of the students using programmed instruction was not significantly greater than that of the students being taught by the traditional methods of instruction.

Conclusion and Recommendations

The major conclusion reached was programmed instruction is not a better teaching method than the traditional methods now being used. The major recommendations are the following: 1. Programmed instruction could be best used as supplementary material in a course taught by the traditional methods of instruction. 2. There should be a planned and extensive orientation program for the students before they use the programmed material. 3. If the length of the class period were shortened to thirty minutes, then programmed instruction could be used more effectively in Advanced General Mathematics

at Christian County High School in Hopkinsville, Kentucky.

4. There should be a follow-up study on this experiment to see if the same results would hold when two control groups and two experimental groups are used.

I-29

PROGRAMMED INSTRUCTION IN BASIC MATHEMATICS AT CHRISTIAN COUNTY HIGH SCHOOL

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Russell Douglas Weatherwax

August, 1967

August 1, 1967

To the Graduate Committee:

I am submitting herewith a thesis written by Russell Douglas Weatherwax entitled "Programmed Instruction in Basic Mathematics at Christian County High School." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts in Education, with a major in Mathematics.

George Brotherton
Major Professor

We have read this thesis and recommend its acceptance:

Ellis B. Burns
Minor Professor

William G. Stokes
Third Committee Member

Accepted for the Committee:

William H. Ellis
Director of Graduate Studies

ACKNOWLEDGEMENTS

The author wishes to express sincere gratitude to Mr. George L. Brotherton, major professor in Mathematics, and Dr. Ellis Burns, major professor in Education, who both aided and counseled him during the course of the field work and concluding phases of this study; to Dr. George Ackley and Warren G. Dawson, who aided him in the tabulation of the raw data; to Mrs. Erleen Rogers, supervisor of Christain County High School, and Miss Charlie Ledford, guidance counselor at Christian County High School, who inspired him when the moments looked dark. Appreciation is also extended to Mr. T. W. Stewart, Superintendent of Christain County Schools, and the Christian County Board of Education for the financial support for this new innovation at Christian County High School.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

THE NATURE OF THE PROBLEM

I. INTRODUCTION

Programmed instruction was primarily a theory until the early 1960's when a large amount of educational research began to find applications for it in many areas of education. Educational research took theories of learning and gave them form in a teaching program. The teaching program was scientifically tested, revised and then retested before it could be used as an educational method on its own merits. Programmed instruction helped bridge the gap between learning theory and practical applications of theory to education.

Wilbur Schramm summarizes the development in the following manner: "Indeed, no teaching medium had come into use in such an atmosphere of research-born as it was in the learning laboratory, nurtured on theory and for some years knowing, no friends, except scholars." [1] Edward J. Green explains it this way: "Programmed instruction is the first application of laboratory technique utilized in the study of the learning process to the practical problems of education." [2] Both Green and Schramm agreed programmed

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[1]Wilbur Schramm, "Programmed Instruction", The Fund For the Advancement of Education (New York: 1962), p. 11.

[2]Edward J. Green, The Learning Process and Programmed Instruction (New York: Holt, Rhinholt and Winston, 1963), p. vi

instruction was an asset to education, but that it needed continuous evaluation to test its real effectiveness in education.

II. THE PROBLEM

Statement of the Problem

The purpose of this study was to ascertain the effect, if any, of programmed instruction upon the achievement of the students in Advanced General Mathematics and to compare their achievement to that of students being taught by traditional methods of instruction. This study was a part of the continuous evaluation of programmed instruction.

Delimitation

This study was limited to forty-four students enrolled in Advanced General Mathematics at Christian County High School in Hopkinsville, Kentucky. These students were selected from a total enrollment of ninety-three students taking Advanced General Mathematics. The groups were further limited by the fact that the students' I. Q. scores ranged from seventy-nine to one hundred-fifteen.

The experimental group was limited to the use of the programmed instruction text, Basic Mathematics, which was produced by Encyclopedia Britannica Press. The course contained the following topics: addition and subtraction of whole numbers, multiplication and division of whole numbers, fractions and mixed numbers, decimals and percentage, and measurements.

This course was conducted from December 1, 1966, to April 14, 1967, by the experimental group while the control group used the traditional text, New Applied Mathematics, by Prentice-Hall.

This study was further limited to the meaning of programmed instruction, to the historical development of programmed instruction, and to the statistical data obtained from the Madden-Peak Arithmetic Computation Forms AM and BM.

Significance of the Study

The significance of this study had two facets. First, it was the continuation of research conducted in programmed instruction to test its merit. Second, it was an effort to aid Christian County High School with its selection of programmed material which would meet the needs of the students in Advance General Mathematics.

III. DEFINITION OF TERMS

The terminology of this study follows, in general, the accepted meanings as found in standard reference works within the fields of mathematics and education. Certain terminology used in the context of the study required specific definitions which are given below.

1. Programmed Instruction. Programmed instruction is defined as the sole use of a programmed text by the student with the instructor used only as a reference person.
2. Traditional Instruction. Traditional instruction is defined as the use of a text book, audio visual aids, group work, discussion, and home-work.
3. Experimental group. The experimental group is defined as the group being taught by programmed instruction.
4. Control Group. The control group is defined as the group being taught by traditional instruction.
5. Semester. The semester is defined as the period of time from December 1, 1966, to April 14, 1967.
6. Pre Test. The pre test is defined as the Madden-Peak Arithmetic Computation Form BM administered on September 3, 1966, to both the control group and the experimental group.
7. Post Test. The post test is defined as the Madden-Peak Arithmetic Computation Form AM administered on April 14, 1967, to both the control group and the experimental group.
8. Delayed Test. The delayed test is defined as the Madden-Peak Arithmetic Computation Form BM administered on May 17, 1967, to both the control group and the experimental group.

IV. BASIC ASSUMPTIONS

This study was based on these assumptions:

1. Programmed instruction has an effect on the achievement of the students in mathematics.
2. Traditional instruction has an effect on the achievement of the students in mathematics.
3. Changes in methods of instruction have an effect on the achievement of the students in mathematics.

V. HYPOTHESES

In view of the above considerations the following hypotheses are made:

1. The achievement of the students using programmed instruction will show a significant increase after an interval of one semester.
2. The achievement of the students being taught by the traditional methods of instruction will show a significant increase after an interval of one semester.
3. The achievement of the students using programmed instruction will be significantly higher than

the achievement of the students being taught by the traditional methods of instruction after an interval of one semester.

4. The retention of the students using programmed instruction will show a significant decrease after a month's delay upon the completion of the semester.
5. The retention of the students using the traditional methods of instruction will not show a significant decrease after a month's delay upon completion of the semester.
6. The retention of the students using programmed instruction will be significantly higher than the retention of the students using the traditional methods of instruction after a month's delay upon completion of the semester.

VI. METHODS OF INVESTIGATION

Sources of Data

Data for this study was of two categories:

1. Literary research was conducted using professional publications and research articles.
2. Statistical data was collected from the Madden-Peak Arithmetic Computation Form

AM or BM administered during the courses of study in three separate intervals.

Specifically, the data used to answer the basic hypotheses of the study was gathered from these places:

1. Data in regard to the meaning of programmed instruction and to trace the historical development of programmed instruction was found in magazines, books and abstracts from the Austin Peay State College Library, the Christian County High School Professional Library, and the Joint Library in Nashville, Tennessee. Information on research conducted by the Encyclopaedia Britannica Press, Pilot Mathematics program in Denver, Colorado and Mobile, Alabama, was found in pamphlets furnished by these organizations.
2. Data for the experiment conducted with programmed instruction at Christian County High School was based upon I. Q. scores and raw scores on the Madden-Peak Arithmetic Computation Form AM and BM. Forty-four students were selected from a total population of ninety-three students enrolled in Advanced General Mathematics. These students were paired by I. Q. scores with a difference of no more than four points and by scores on the

Madden-Peak Arithmetic Computation Form BM with a difference of no more than four points. One group, defined as the control group, was taught by the traditional methods; and the other group, defined as the experimental group, was taught by programmed instruction. Other data consisted of scores of the two groups on the Madden-Peak Arithmetic Computation Form AM at the end of the semester and of scores of the two groups on the Madden-Peak Arithmetic Computation Form BM a month after the end of the semester.

Analysis of the Data

This study was a combination of descriptive analysis of programmed instruction as background material of the study and a statistical analysis of the problem of the study.

In the analysis, literary research was required to define programmed instruction and to discuss the historical development of programmed instruction. The analysis measured the students' achievement in Advanced General Mathematics before the use of programmed instruction. It also compared the achievement of the students using programmed instruction with those using traditional instruction after one semester. A month later a third measurement was taken of both groups to evaluate their retention.

VII. ORGANIZATION OF THE STUDY

The first chapter includes the problem limitation, definition of terms, basic assumptions, hypothesis, and purpose for the study. Chapter II is devoted to related literature which deals with the following topics: the meaning of programmed instruction and the history of programmed instruction. Chapter III presents the statistical data obtained from the Madden-Peak Arithmetic Computation Forms AM and BM given in three separate intervals. Chapter IV reviews the finding of the study and recommendations for future use of programmed instruction.

CHAPTER II

THE MEANING AND HISTORY OF PROGRAMMED INSTRUCTION

I. MEANING OF PROGRAMMED INSTRUCTION

To understand the meaning of programmed instruction it is important to investigate how learning theory is related and used in programmed instruction. Learning should be a lively process instead of a dull process. If the student has interaction with the material that is being taught, he will gain much more than just receiving a basic understanding of what is being taught. In programmed instruction the student should have this interaction with the material due to the design of the material being taught.

If the student is constantly aware of his progress, he will tend to seek improvement. Programmed instruction provides the student with an immediate check after each question when he is required to respond.

Programmed instruction provides only the correct response which tends to block the student from incorrect response. Therefore, the student will tend to remember and react only in terms of the correct response in future situations. People learn and change their behavior on the basis of the consequences they face due to their actions. If they have a negative consequence to their activities,

they will not usually repeat those activities. On the other hand, if they have a positive consequence to their activities, they will repeat those activities.

One major advantage of programmed instruction is the immediate reinforcement to each new stimuli. As the student progresses through the program, the earilier stimulus receives intermittent reinforcement while the present stimulus receives immediate reinforcement. This reinforcement to the student's response increases the length of time a student will persist at an act, quickens his speed, and increases his interest in learning. In programmed instruction there is no reinforcement following an incorrect response. Therefore, the student reacts only to correct reinforcements. By shaping the material in a sequencial order from simple to complex with the difference degrees of reinforcements, the student's learning can be guided to a complex state of competence.

With an understanding of how learning theory is related to programmed instruction, the meaning of programmed instruction becomes more apparent. Jonathan W. Varty summarized programmed instruction as the instruction of material which contains "small steps, self-pacing, active response, immediate knowledge of success, and self-testing." [1]

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[1]Jonathan W. Varty, "Programmed Instruction for Prospective Teachers" The Educational Forum, XXVIII (January, 1964) pp. 227-228.

Socrates of the Greek Empire could be called the father of programmed instruction because of his question method of instruction. The student posed a question to Socrates who, in turn, posed a simplified statement or question to the student. When the student responded to the question, Socrates, then posed another question based upon the original question. In time the student would answer his own original question.

Socrates developed a mathematical program for geometry which passed on in history by Plato in the dialogue of Meno. [2a] In Table I, there is a portion of Socrates' program compared with a portion of a sequence of a modern program.

Aristotle, a student of Socrates, introduced the step-by-step method. This method is a definite integral part of the definition of programmed instruction according to Jonathan W. Varty, as noted earlier in this study.

As the Roman Empire began to spread power and influence over the Mediterranean Sea region, they adapted much of the Greek style of government, religion, and education. The question method of Socrates and the step-by-step method of Aristotle were preserved for future generations of the Roman

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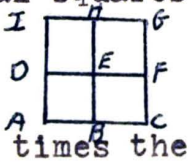
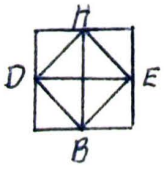
[2a]Jerome P. Lysaught and Clarence M. Williams, A Guide to Programmed Instruction, (New York: John Wiley and Sons, Inc., 1963) p. 3-4.

Civilization. The Roman Civilization did not add any new principles or facets to programmed instruction.

When the barbaric tribes of Northern Europe invaded and conquered the Roman Empire, the rest of the known world was going into a period known as the Middle Ages. During the period of the Middle Ages, it seemed that most development in government and education was at a standstill.

TABLE I

"A COMPARISON OF ITEMS FROM TWO DEVELOPMENTAL INSTRUCTIONAL SEQUENCES" [2b]

Stimulus	
S-1. Then here we have four equal squares 	S-1. A doctor taps your knee with a rubber hammer to test your '_____'.
R-1. Yes.	Response R-1. Reflexes
S-2. How many times the size of the first square (ABED) is the whole (ACGI)?	S-2. If your reflexes are normal, your leg _____ to the tap on the knee with a slight kick.
R-2. Four times.	R-2. Responds (or reacts).
S-3. We want one double the size. How does this line going from corner to corner cut each of the squares in half? 	S-3. In the knee jerk or patellar tendon reflex, the kick of the leg is the _____ to the tap on the knee.

[2b] Lysaught and Williams, Ibid.

R-3. Yes.

S-4. And these are four equal lines enclosing this area (BEHD) (see S-3 figure).

R-4. Yes.

S-5. Look at our four squares. Has not each line cut off the inner half of each of them? (see S-3)

R-5. Yes.

S-6. And how many halves are there in the figure? (BEHD) (see S-3)

R-6. Four.

S-7. Right. And how many halves are there in the figure (ABCD) see S-1?

R-7. Two.

S-8. And what is the relation of four or two?

R-8. Double.

R-3. Responses (or reactions).

S-4. The stimulating object used by the doctor to elicit a knee jerk is a (n) _____.

R-4. Hammer (mallet).

S-5. The stimulus which elicits a knee jerk is the _____ delivered by the so called stimulus object or hammer.

R-5. Tap (blow).

S-6. In the knee jerk reflex, we call the rubber hammer the ____ and the tap or blow the _____.

R-6. A. Stimulus object
B. Stimulus

S-7. An event is explained when its cause is identified. The cause or explanation of the knee jerk is, technically, the _____ which elicits it.

R-7. Stimulus

S-8. Technically speaking a reflex involves an eliciting an stimulus in a process called eliciatation. A stimulus _____ a response.

R-8. Elicits.

Programmed instruction took form in the apprenticeship method of the guilds. A student would learn a trade under the supervision of a skilled craftsmen of the guild. The skilled craftsmen would provide the student with the stimuli expecting the student to give the correct response.

As Western Europe moved out of the Middle Ages and through the period of the Renaissance and the Reformation, programmed instruction continued in the form of either the question method, step-by-step method or apprenticeship method. During the 1800's and the early 1900's programmed instruction took the form of teaching machines rather than a program or a method of instruction. W. Lee Garner pointed this out in the following statement:

> Early devices rather than programs survived. The U. S. Patent Office granted a patent to H. Chard in 1809 for a device in teaching reading. Halcyon Skinner developed and patented another device in 1866 to teach spelling. B. F. Skinner has called this the first real teaching machine. And Moria Montessori patented a device in 1914 to train the sense of touch. 3

S. L. Pressey, a psychologist in the 1920's, implied that teaching machines must be based upon the learning theory in order for the machines to be valuable to education. Pressey received very little professional help from his colleagues which caused him to become disheartened and to abandon his investigation.

3W. Lee Garner, Programmed Instruction, (New York: The Center for Applied Research in Education Inc., 1966) p. 8.

B. F. Skinner developed programmed instruction without the use of teaching machines. With the information from the investigations of Pavlov and J. B. Watson, Skinner tested his theory of Stimulus-Response bond in 1943 with the use of animals. In one experiment Skinner was able to train pigeons to bowl; and in another experiment, he used mice in a warhead of a bomb to direct it on target. Skinner believed this learning process could be transferred to humans. The Federal Government found Skinner's theory useful in its training program for servicemen who had dropped out of school.

As a result of several experiments the following conclusion was reached:

> Research leaves us in no doubt that programs do teach. A great deal of learning seems to take place, regardless of the kind of programs or kinds of students.[4]

The crisis in public education came on October 4, 1957 with the launching of Sputnick which marked the beginning of the Space Age. This event made the American public and educators aware of some of the problems in American education. The American public and the educators felt that the students were not getting an adequate education. It seemed that they could not react and apply adequately what they had learned to the problems of a scientifically oriented country.

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[4] Wilbur Schramm, "Programmed Instruction", The Fund for the Advancement of Education. New York: 1962, p. 11.

To assist with the problem, educators turned to Skinner's theory of programmed instruction. Outgrowths of Skinner's concept resulted in the following methods of programmed instruction: Crowder's branching or scramble program, Mager's learner-controlled instruction, Stolyrow's idiographic programming, Gilbert's Mathetics method, and Rothkopf's Mathemagenics system.

Crowder's branching program answered the question, why, while the linear program of Skinner failed to provide understanding. Crowder provided a selection of answers to the stated stimuli. The incorrect response of the student would be reinforced through a branch of simplified material to show the student why his answer was incorrect. The results of an experiment using Skinner's method and Crowder's method are as follows:

> A few experiments have even tried scrambling the order of the short program and the most common result is no significant difference between the learning from the scrambled and the ordered program. [5]

In 1958, Robert F. Mager introduced the learner controlled instruction. Mager based his philosophy on the following assumption:

> If an instructor were to behave as an information store rather than as the information transmitter and put himself under the control of a learner for a few hours, he might actually observe the process by which anyone learns. [6]

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[5] Ibid., p. 12.

[6] Garner, op. cit., p. 21.

Mager's method still remains in the experimental stages.

Idiographic programming by Stolyrow indicates the use of a computer station for each student. The American public at present has not supported this project because of the cost.

T. F. Gilbert in 1962 introduced to Mathematics the theory of doing which is presently under development.

> Gilbert believes that students will work to be right only to the extent that they have been deprived in the past of such information; after awhile, immediate knowledge of results loses its re-enforcing strength. [7]

The preceding paragraphs have shown the development of programmed instruction. Now the investigation will turn to some of the current studies of programmed instruction.

Programmed instruction in the Denver area is significant as the school system was the first to release a teacher, Jerry E. Read, to learn and to develop a program in English 2600. The decision of the school board to release Read to develop programmed instruction encouraged some other systems to investigate his program and to develop new programs of their own. Many of the English teachers were pleased with English 2600 because it took over some of their drill and remedial responsibilities. [8]

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[7] Ibid., p. 26.

[8] Edling, Foshay, Ginther, John, Schramm, and Thelen "Four Case Studies of Programmed Instruction" The Fund for the Advancement of Education, (New York: 1964) p. 27.

Programmed instruction in Manhasset Junior High School tested English 2600 in grades seven, eight, and nine. The classes in question were selected on an experimental basis and were given a pre examination and a post examination. There was some opposition at first with the experiment, but it soon faded away. The teacher found that programmed instruction did improve the students' education and provided for individualized instruction in compositional writing. Furthermore, it encouraged the teachers to co-operate more closely with each other. [9]

In the Chicago area an experiment with programmed instruction showed that programmed instruction should only serve as an aid to instruction. The public school system also noticed that it was better to use programmed instruction in a short class period instead of a regular class period. The use of programmed instruction should be planned in relationship with the total instructional program of any school. [10]

The Pilot Mathematics Program, constructed for the slow learner in the Denver Public Schools, used programmed instruction. The Pilot Mathematics Program took students in the seventh grade level with an I. Q. range from 74 to 87, and their achievement in Basic Mathematics at the beginning

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[9] Ibid., p. 26.

[10] Ibid., pp. 48-49.

of the study was between two months to five months below expectancy. With the use of programmed instruction from September, 1963 to May, 1964, the students' achievement improved to a range between two months to six months above expectancy. These results were based upon the California Arithmetic Test Forms W, X, and Z. [11]

The City School System of Roanoke, Virginia conducted an experiment with TEMAC programmed material with their eighth grade students in the area of Algebra I. This is unusual because Algebra I is usually not introduced until the ninth grade. Only one student failed to perform satisfactorily on the standardized examination used as the criteria in the City Schools System of Roanoke, Virginia. [12]

After investigation of the studies mentioned above, it was noticed that the use of programmed material was mainly in the seven, eight, and nineth grade block. These projects showed that programmed instruction was an aid, could instruct large number of students at the same time, and provided better individualized instruction.

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[11] "Math for the Slow Learner" A Pilot Mathematics Program Baker Junior High School, Denver Public Schools 1964, pp. 3-4.

[12] E. W. Rushton, Programmed Learning in the Roanoke, Virginia, City School System, unpublished paper dated January 30, 1961. TEMAC Programmed Learning Materials Report No. 2, Wilmette, Ill. E.B.F. April, 1961.

CHAPTER III

STATISTICAL DATA

Chapter two investigated the meaning of programmed instruction, the historical background of programmed instruction, and presented information on studies taking place in programmed instruction. In this chapter the investigation will turn to the collection of data and the findings which resulted from its analysis.

I. MATCHING CONTROL GROUP AND EXPERIMENTAL GROUP

The twenty-two students in the control group and the twenty-two students in the experimental group were matched in pairs. The students were paired on the basis of I. Q. scores obtained from their cumulative records and scores on the Madden-Peak Arithmetic Computation Form BM which was administered on September 3, 1966. Each pair had a difference of no more than four points on the I. Q. score and on the Madden-Peak Arithmetic Computation Form BM. The matching of the control group and experimental group is found in Table II.

A t-test was used to determine whether the difference between the means of the scores of the two groups on the Madden-Peak Arithmetic Computation Form BM was significant. The scores of the two groups are given in Table III. The

TABLE II

PRE-TEST AND I. Q. SCORES OF THE CONTROL AND EXPERIMENTAL GROUPS

EXPERIMENTAL GROUP

Student Number	Pre Test	I. Q. Score
1	27	84
2	60	115
3	40	94
4	42	106
5	33	96
6	39	97
7	28	79
8	36	110
9	34	97
10	40	112
11	30	85
12	31	97
13	30	82
14	47	108
15	24	88
16	51	107
17	34	105
18	29	99
19	34	83
20	24	108
21	48	108
22	34	110

Mean of the Madden Peak pre test equals 36.136 for the experimental group.

Mean of the Otis I. Q. score equals 98.182 for the experimental group.

CONTROL GROUP

Student Number	Pre Test	I. Q. Score
1	27	83
2	61	115
3	40	91
4	43	103
5	33	96
6	36	99
7	29	83
8	38	109
9	36	93
10	38	112
11	30	85
12	31	96
13	29	80
14	47	108
15	26	85
16	54	108
17	37	103
18	27	99
19	35	80
20	28	104
21	47	110
22	34	111

Mean of the Madden Peak pre test equals 36.637 for the control group.

Mean of the Otis I. Q. score equals 97.409 for the control group.

TABLE III

T-TEST BETWEEN THE CONTROL AND EXPERIMENTAL GROUPS BY THE USE OF DIFFERENCES FOR THE PRE-TEST

STUDENT NUMBER	PRE EXPERIMENTAL SCORE	PRE CONTROL SCORE	DIFFERENCE	DIFFERENCE SQUARE
1	27	27	0	0
2	60	61	1	1
3	40	40	0	0
4	42	43	1	1
5	33	33	0	0
6	39	36	-3	9
7	28	29	1	1
8	36	38	2	4
9	34	36	2	4
10	40	38	-2	4
11	30	30	0	0
12	31	31	0	0
13	30	29	-1	1
14	47	47	0	0
15	24	26	2	4
16	51	54	3	9
17	34	37	3	9
18	29	27	-2	4
19	34	35	1	1
20	24	28	4	16
21	48	47	-1	1
22	34	34	0	0
Totals	795	806	20	69

N=22 $M_1 = 36.136$ $M_2 = 36.637$ $\Sigma D(+) = 20$ $\Sigma D(-) = -9$ $\Sigma D = 11$ $\Sigma D^2 = 69$ $MD = .500$

$$\sigma_D = \sqrt{\frac{\Sigma D^2}{N} - (M_D)^2}$$

$$\sigma_D = \sqrt{\frac{69}{20} - (.5)^2}$$

$$\sigma_D = 1.695$$

$$\sigma_{M_D} = \frac{\sigma_D}{\sqrt{N-1}} = \frac{1.965}{\sqrt{21}} = .346$$

$$t = \frac{M_D}{\sigma_{M_D}} = \frac{.500}{.346} = 1.445$$

Mean of differences is .500
Standard deviation of differences is 1.695
Standard error of differences is .346
T-test equals 1.445
Values of t at the 1% levels of significant is 2.831 for twenty-one degrees of freedom

difference method was used and the value of t was 1.445. At the 1% level of confidence, there was no significant difference between the means. This indicated there was no significant difference in the achievement of the two groups at the beginning of the experiment.

II. POST TEST RESULTS

On April 14, 1967, when the experimental group finished the programmed instruction course, the Madden-Peak Arithmetic Computation Form AM was administered to both groups of students. The post test scores and the pre test scores of the two groups are found in Table IV.

A t-test was made to determine whether the difference between the means of the scores on the pre test and the scores on the post test of the control group was significant. The value of t was 4.582. A t-test was performed to determine whether the difference between the means of the scores on the pre test and the scores on the post test of the experimental group was significant. The value of t was 5.144. At the 1% level of confidence the scores showed differences above 2.831. These t-tests are found in Table IV. This indicates there was significant achievement made in both groups from September 3, 1966 to April 14, 1967.

A t-test was made to determine whether the difference between the means of the post scores of the control group

TABLE IV

T-TEST OF DIFFERENCE FOR CONTROL AND EXPERIMENTAL GROUPS FOR PRE-TEST AND POST TEST

CONTROL GROUP

STUDENT NUMBER	PRE SCORE	POST SCORE	DIFFERENCE SCORE
1	27	40	13
2	61	66	5
3	40	58	18
4	43	51	8
5	33	45	12
6	36	46	10
7	29	48	18
8	38	40	2
9	36	46	10
10	38	31	-7
11	30	33	3
12	31	35	4
13	29	56	27
14	47	63	16
15	26	42	16
16	54	53	-1
17	37	37	0
18	27	41	14
19	35	38	3
20	28	26	-2
21	47	55	8
22	34	45	11
Totals	806	995	193

N=22 $M_1 = 36.637$ $M_2 = 45.227$ $M_D = 8.591$ $\Sigma D^2 = 3001$

$$\sigma_D = \sqrt{\frac{\Sigma D^2}{N} - (m_D)^2}$$

$$\sigma_D = \sqrt{\frac{3001}{21} - (8.591)^2}$$

$$\sigma_D = 8.733$$

$$\sigma_{M_D} = \frac{\sigma_D}{\sqrt{N-1}}$$

$$\sigma_{M_D} = \frac{8.733}{\sqrt{21}}$$

$$= 1.906$$

$$t = \frac{M_D}{\sigma_{M_D}} = \frac{8.733}{1.906} = 4.582$$

Mean of difference is 8.591
Standard deviation of difference is 8.733
Standard error of the mean difference is 2.085
T-test equals 4.582
Values of t at the 1% levels of significance at twenty-one degrees of freedom is 2.831.

T-TEST OF DIFFERENCE FOR CONTROL AND EXPERIMENTAL GROUPS FOR PRE-TEST AND POST TEST

EXPERIMENTAL GROUP

STUDENT NUMBER	PRE SCORE	POST SCORE	DIFFERENCE SCORE
1	27	38	11
2	60	60	0
3	40	64	24
4	42	52	10
5	33	37	4
6	39	55	16
7	28	37	9
8	36	41	5
9	34	24	10
10	40	53	23
11	30	28	-2
12	31	47	16
13	30	46	16
14	47	46	-1
15	24	45	21
16	51	63	12
17	34	52	18
18	29	37	8
19	34	38	4
20	24	46	22
21	48	53	5
22	34	59	25
Totals	795	1031	236

N=22 $M_1 = 36.136$ $M_2 = 46.864$ $M_D = 10.727$

$\epsilon D^2 = 4540$

$$\sigma D = \sqrt{\frac{\epsilon D^2}{N} - (M_D)^2} \qquad \sigma M_D = \frac{\sigma D}{\sqrt{N-1}}$$

$$\sigma D = \sqrt{\frac{4540}{22} - (10.727)^2} \qquad \sigma M_D = \frac{9.554}{\sqrt{21}}$$

$\sigma D = 9.554$ $= 2.085$

$$t = \frac{M_D}{\sigma M_D} = \frac{10.727}{2.085} = 5.144$$

Mean of difference is 10.727
Standard deviation of difference is 9.554
Standard error of the mean difference is 2.085
T-test equals 5.144
Values of t at the 1% levels of significance at twenty-one degrees of freedom is 2.831

and the post test scores of the experimental group was significant. Using the difference method, the value of t was .612. This score at the 1% level of confidence showed no significant difference between the means. This indicates there is not a significant difference between the achievement in the two groups. The statistical computation can be found on Table V.

III. DELAYED TEST RESULTS

On May 17, 1967, approximately a month after the experimental group finished the programmed instruction course, the Madden-Peak Arithmetic Computation Form BM was administered to both groups of students. This test was called the delayed test, and its purpose was to test the retention of achievement of the students in both groups. The delayed test scores, the pre test scores, and the post test scores of the two groups are given in Table VI.

A t-test was made to determine whether the difference between the means of the post test scores and the delayed test scores of the control group was significant. The value of t was 1.817. A t-test was conducted to determine whether the difference between the means of the post test scores and the delayed test scores of the experimental group was significant. The value of t was 1.163. At the 1% level of confidence the scores showed a difference

TABLE V

T-TEST BETWEEN THE CONTROL AND EXPERIMENTAL GROUPS BY THE USE OF DIFFERENCES FOR POST-TEST

STUDENT NUMBER	POST EXPERIMENTAL SCORE	POST CONTROL SCORE	DIFFERENCE	DIFFERENCE SQUARE
1	38	40	2	4
2	60	66	6	36
3	64	58	-6	36
4	52	51	-1	1
5	37	45	8	64
6	55	46	-9	81
7	37	48	11	121
8	41	40	-1	1
9	24	46	22	484
10	63	31	-32	1024
11	28	33	5	25
12	47	35	-12	144
13	46	56	10	100
14	46	63	17	289
15	45	42	-3	9
16	63	53	-10	100
17	52	37	-15	225
18	37	41	4	16
19	38	38	0	0
20	46	26	-20	400
21	53	55	2	4
22	59	45	-14	196
Totals	1031	995	36	3360

N=22 $M_1 = 46.864$ $M_2 = 45.227$ $M_D = 1.636$ $\Sigma D^2 = 3360$

$$\sigma D = \sqrt{\frac{\Sigma D^2}{N} - (M_D)^2} \qquad \sigma M_D = \frac{\sigma D}{\sqrt{N-1}} = \frac{12.250}{\sqrt{21}} = 2.673$$

$$\sigma D = \sqrt{\frac{3360}{22} - 2.676}$$

$\sigma D = 12.250$ $\qquad t = \frac{M_D}{\sigma M_D} = \frac{1.636}{2.673} = .612$

Mean of difference is 1.636.
Standard deviation of difference is 12.250.
Standard error of difference is 2.673.
T-test equals .612.
Values of t at the 1% levels of significant is 2.831 for twenty-one degrees of freedom.

TABLE VI

PRE-TEST POST TEST AND DELAYED TEST SCORES FOR CONTROL AND EXPERIMENTAL GROUPS

	EXPERIMENTAL GROUP			CONTROL GROUP		
STUDENT NUMBER	PRE SCORE	POST SCORE	DELAYED SCORE	PRE SCORE	POST SCORE	DELAYED SCORE
1	27	38	38	27	40	56
2	60	60	63	61	66	68
3	40	64	44	40	58	51
4	42	52	64	43	51	56
5	33	37	41	33	45	44
6	39	55	39	36	46	35
7	28	37	36	29	48	42
8	36	41	50	38	40	41
9	34	24	40	36	46	45
10	40	63	60	38	31	41
11	30	28	37	30	33	44
12	31	47	52	31	35	38
13	30	46	37	29	56	48
14	47	46	56	47	63	67
15	27	45	45	26	42	47
16	51	63	51	54	53	59
17	34	52	56	37	37	53
18	29	37	40	27	41	46
19	34	38	57	35	38	43
20	24	46	53	28	26	28
21	48	53	59	47	55	60
22	34	59	60	34	45	43
Totals	795	1031	1078	806	995	1055

below 2.831. These t-tests are found in Table VII. This indicates there was no significant decrease in retention in both groups from April 14, 1967 to May 17, 1967.

A t-test was made to determine whether the difference between the means of the delayed test scores of the control group and the delayed test scores of the experimental group was significant. Using the difference method, the value of t was .454. This value showed no significant difference between the means. This indicates there is not a significant difference between retention of the two groups. This t-test also showed there is not a significant difference between the achievement in the two groups from September 3, 1966 to May 17, 1967.

TABLE VII

T-TEST OF DIFFERENCES FOR CONTROL AND EXPERIMENTAL FOR POST-TEST AND DELAYED TEST

CONTROL GROUP

STUDENT NUMBER	POST SCORE	DELAYED SCORE	DIFFERENCE SCORE	DIFFERENCE SQUARED
1	40	56	16	256
2	66	68	2	4
3	58	51	-7	49
4	51	56	5	25
5	45	44	-1	1
6	46	35	-11	121
7	48	42	-6	36
8	40	41	1	1
9	46	45	-1	1
10	31	41	10	100
11	33	44	11	121
12	35	38	3	9
13	56	48	-8	64
14	63	67	4	16
15	42	47	5	25
16	53	59	6	36
17	37	53	16	256
18	41	46	5	25
19	38	43	5	25
20	26	28	2	4
21	55	60	5	25
22	45	43	-2	4
Totals	995	1055	60	1204

$N = 22 \quad M_1 = 45.227 \quad M_2 = 47.955 \quad M_D = 2.727 \quad \Sigma D^2 = 1204$

$$\sigma D = \sqrt{\frac{\Sigma D^2}{N} - (M_D)^2}$$

$$\sigma D = \sqrt{\frac{1204}{22} - 7.437}$$

$$\sigma D = 6.877$$

$$\sigma M_D = \frac{\sigma D}{\sqrt{N - 1}} = \frac{6.877}{\sqrt{21}} = 1.501$$

$$t = \frac{M_D}{\sigma M_D} = \frac{2.727}{1.501} = 1.817$$

Mean of differences is 2.727.
Standard deviation of differences is 6.877.
Standard error of differences is 1.501.
T-test equals 1.817.
Values of t at the one percent level of significance is 2.831 for twenty-one degrees of freedom.

TABLE VII (CONT.)

T-TEST OF DIFFERENCE FOR CONTROL AND EXPERIMENTAL GROUPS FOR POST-TEST AND DELAYED TEST

EXPERIMENTAL GROUP

STUDENT NUMBER	POST SCORE	DELAYED SCORE	DIFFERENCE SCORE	DIFFERENCE SQUARED
1	38	38	0	0
2	60	63	3	9
3	64	44	-20	400
4	52	64	12	144
5	37	41	4	16
6	55	39	-14	196
7	37	36	-1	1
8	41	50	9	81
9	24	40	16	256
10	63	60	-3	9
11	28	37	9	81
12	47	52	5	25
13	46	37	-9	81
14	46	56	10	100
15	45	45	0	0
16	63	51	-12	144
17	52	56	4	16
18	37	40	3	9
19	38	57	19	361
20	46	53	7	49
21	53	59	6	36
22	59	60	1	1
Totals	1031	1078	47	2015

N=22 $M_1 = 46.864$ $M_2 = 49.000$ $M_D = 2.136$ $\Sigma D^2 = 2015$

$$\sigma_D = \sqrt{\frac{\Sigma D^2}{N} - (M_D)^2}$$

$$\sigma_D = \sqrt{\frac{2015}{22} - 4.562}$$

$$\sigma_D = 9.329$$

$$\sigma M_D = \frac{\sigma D}{\sqrt{N-1}} = \frac{9.329}{\sqrt{21}} = 2.036$$

$$t = \frac{2.136}{1.836} = 1.163$$

Mean of the differences is 2.136.
Standard deviation of differences is 9.329.
Standard error of differences is 2.036.
T-test equals 1.163.
Values of t at the one percent level of significance is 2.831 for twenty-one degrees of freedom.

TABLE VIII

T-TEST BETWEEN THE CONTROL AND EXPERIMENTAL GROUP FOR THE DELAYED SCORE ON THE BASIS OF DIFFERENCE FOR DELAYED-TEST

STUDENT NUMBER	DELAYED EXPERIMENTAL SCORE	DELAYED CONTROL SCORE	DIFFERENCE SCORE	DIFFERENCE SQUARED
1	38	56	18	324
2	63	68	5	25
3	44	51	7	49
4	64	56	-8	64
5	41	44	3	9
6	39	35	-4	16
7	36	42	6	36
8	50	41	-9	81
9	40	45	5	25
10	60	41	-19	361
11	37	44	7	49
12	51	38	-14	196
13	37	48	11	121
14	56	67	11	121
15	45	47	2	4
16	51	59	8	64
17	56	53	-3	9
18	40	46	6	36
19	57	43	-14	196
20	53	28	-25	625
21	59	60	1	1
22	60	43	-17	289
Totals	1078	1055	-23	2801

N=22 $M_1 = 49.000$ $M_2 = 47.955$ $M_D = 1.046$ $\Sigma D^2 = 2801$

$$\sigma_D = \sqrt{\frac{\Sigma D^2}{N} - (MD)^2}$$

$$\sigma_D = \sqrt{\frac{2801}{22} - 1.094}$$

$$\sigma_D = 11.284$$

$$\sigma_{M_D} = \frac{\sigma_D}{\sqrt{N-1}} = \frac{11.284}{\sqrt{21}} = 2.305$$

$$t = \frac{M_D}{\sigma_{M_D}} = \frac{1.046}{2.305} = .454$$

Mean of differences is 1.046.
Standard deviation of differences is 11.284.
Standard error of differences is 2.305.
T-test equals .454.
Values of t at the one percent level of significance is 2.831 for twenty-one degrees of freedom.

CHAPTER IV

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

I. FINDINGS

When the hypothesis were tested using the statistical analysis the following results were found:

1. Since the achievement of the students using programmed instruction showed a significant increase after an interval of one semester, the first hypothesis must be accepted.
2. Since the achievement of the students using the traditional methods of instruction showed a significant increase after an interval of one semester, the second hypothesis must be accepted.
3. Since the achievement of the students using programmed instruction was not significantly higher than that of the students using traditional methods of instruction after an interval of one semester, the third hypothesis must be rejected.
4. Since the retention of the students using programmed instruction did not show a significant decrease after a month's delay upon the completion of the semester, the fourth hypothesis must be accepted.
5. Since the retention of the students using traditional methods of instruction did not show a significant decrease after a month's delay upon completion of the semester, the fifth hypothesis must be accepted.

6. Since the retention of the students using programmed instruction was not significantly less than that of the students using traditional methods of instruction after a month's delay upon completion of the semester, the sixth hypothesis must be rejected.

II. CONCLUSIONS AND RECOMMENDATIONS

The conclusions of this study are the following: (1) Since the achievement of the students using programmed instruction was not significantly better than that of the students using traditional methods of instruction, then programmed instruction has no greater effect than the traditional methods of instruction on the amount of achievement in mathematics. (2) Since the retention of the students using programmed instruction was not significantly better than that of the students using the traditional methods of instruction, then programmed instruction has no greater effect on the amount of retention of the students. These two specific conclusions point to a general conclusion that programmed instruction is no better than the traditional methods of instruction in Advanced General Mathematics at Christian County High School.

The following recommendations are proposed about programmed instruction in Advanced General Mathematics:

1. Programmed instruction could be best used as supplementary material in a course taught by the traditional methods of instruction. There are many topics in mathematics where the slower student needs more work or a clearer explanation and some areas where the more talented student would like to explore. Well selected programmed material would provide aid for both types of students.
2. A planned and extensive orientation program for the student should be conducted before the use of programmed instruction. This would prepare the student for the different type of instruction and would acquaint the student with its purposes and techniques. It is believed that this would aid the student in getting the greatest possible benefit out of programmed instruction.
3. Teachers planning to use programmed material should investigate the nature of programmed instruction in relationship to the learning process. For a teacher to utilize programmed material, he would need an understanding of its effects on the student's learning. Realizing this, the teacher might be able to use it more effectively to the student's advantage.

4. The use of two classes for a control group and two classes for an experimental group would be better, since the experimental group used in this study seemed to be continuously interrupted for club meetings, assemblies, and other activities.
5. Programmed instruction could be used in Advanced General Mathematics at Christian County High School if the length of the class period were shortened to about thirty minutes. A fifty-minute period is too long for a class in programmed instruction, because the student seems to tire and become bored after about thirty minutes. It must be noted that this study showed there was no difference in achievement in the control group and the experimental group. This would suggest a future study to show that a period of thirty minutes using programmed instruction would produce the same amount of achievement as a period of fifty minutes using the traditional methods of instruction.

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