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# The effects on arithmetic achievement as the result of an experimental plan of reteaching

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BOSTON UNIVERSITY  
SCHOOL OF EDUCATION

Thesis

THE EFFECTS ON ARITHMETIC ACHIEVEMENT  
AS THE RESULT OF AN EXPERIMENTAL  
PLAN OF RETEACHING

Submitted by

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(B.S., Boston University, 1957)

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## APPENDIX

The following is a list of the names of the members of the committee who have read and approved the report of the committee on the subject of the proposed changes in the curriculum of the Department of Education.

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**Assistant Professor of Education**

**Second Reader: Dr. J. Fred Weaver**

**Associate Dean and Director of**

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## ACKNOWLEDGEMENT

To Professor J. Franklin Fitzgerald for his guidance and generous assistance, to George B. Rochfort, Jr. for his technical assistance, and to both for their constant encouragement, I wish to express my sincere appreciation.

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## CHAPTER I

### INTRODUCTION

Practice or drill has been a valuable part of learning. Practice procedures apply to all aspects of learning and should be used. The classroom teacher can think of practice as simply additional drill or mere repetition; or he can think of practice as an opportunity to reteach whereby he provides the child with another opportunity to relearn, or to learn better, or to learn more about that which has been taught before.<sup>1</sup>

### THE PROBLEM

#### Statement of the Problem

The problem in this study was to determine the effect on seventh grade pupils of a particular method of reteaching the fundamental processes in two areas of arithmetic achievement: namely, concepts and problem solving.

The problem was subdivided (1) to determine, at three levels of ability, whether an experimental section using a systematic method of reteaching would show greater gains in

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<sup>1</sup>Robert L. Morton, "The Review versus the Telescoped Reteaching of the Work of Preceding Grades," Mathematics Teacher, 39:225-28, May, 1946.



arithmetic achievement in the areas of concepts and problem<sup>2</sup> solving than a control section not using the method, and (2) to compare the achievement of the experimental and the control sections in those areas of arithmetic concepts involving whole numbers, fractions and decimals.

### Definitions of Terms

Experimental Plan. The experimental plan, as used in this study, was defined as the reteaching of the fundamental processes of arithmetic, using a horizontal algorithm, for a short period of time at the beginning of each class period. The plan is explained in detail in Chapter II.

Horizontal Algorithm. Horizontal algorithm was defined as the recording of computation in the form  $.04 + .1 = ?$  as opposed to the vertical form  $\begin{array}{r} .04 \\ + .1 \\ \hline \end{array}$ . This algorithm is further illustrated in Chapter II under the explanation of the experimental plan.

Reteaching. Reteaching was defined as providing an opportunity for the pupil to learn that which he has previously failed to learn, that which he at first only partially learned, that which he had learned and has forgotten, or teaching again, at a higher and more mature

level, what has been taught before.<sup>2</sup>

Practice (drill). Practice (drill) indicated "those aspects of learning and teaching that possess elements of similarity or sameness which repeat or recur."<sup>3</sup>

Fundamental Processes. Fundamental processes was defined as the operations of addition, subtraction, multiplication, and division on whole numbers, fractions, decimals.

Problem. A problem was defined as a quantitative question that is answered by means other than a memorized response.<sup>4</sup> A problem may be verbal or non-verbal. A problem implies a need and a willingness to find a solution.

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<sup>2</sup>Robert L. Morton, "Teaching Arithmetic," What Research Says to the Teacher, No. 2, Departments of Classroom Teachers, American Educational Research Association of the National Education Association, (Washington, D.C.: National Education Association, 1953), p. 12.

<sup>3</sup>Ben A. Sueltz, Drill-Practice-Recurring Experience, Twenty-first Yearbook of the National Council of Teachers of Mathematics, (Washington, D.C., 1953).

<sup>4</sup>John L. Marks, C. Richard Purdy, and Lucien B. Kinney, Teaching Arithmetic for Understanding (New York: McGraw-Hill Book Company, 1958), p. 52.

Arithmetic Concepts. Arithmetic concepts was defined by the author of the "Iowa Tests of Basic Skills" in the Manual for Administrators, Supervisors, and Counselors in his explanation of Test A-1 concerning arithmetic concepts as follows:

In this test the present-day philosophy of teaching arithmetic is represented as closely as possible. The emphasis is on understanding of the number system, of terms, processes, and operations, and of units of measurement.

The following classification of skills was used in building the test:

Concepts Involving Knowledge of the Number System: counting; relative values of numbers; cardinal and ordinal numbers; odd and even numbers; positive and negative numbers; Roman numbers; money numbers: reading and writing, recognizing and comparing values of U.S. coins, making change; terms (right and left, pair, down, etc.); averaging; place value and zero as a place holder.

Concepts Involving Whole Numbers: reading and writing; rounding; fundamental operations: ways to perform, relationships among number facts, terms (sum, difference, product, quotient, etc.), estimating results.

Concepts Involving Fractions: reading and writing; part of a whole and part of a group; relative sizes; reducing; terms (like and unlike, proper and improper, common denominator, etc.); fundamental operations: ways to perform, estimating results.

Concepts Involving Decimals: reading and writing; rounding; relative sizes; fundamental operations: ways to perform, estimating results.

Concepts Involving Per Cents: meaning and use; fraction, decimal, and per cent equivalents.

Concepts Involving Standard Measures: telling time and time zones; knowledge of calendar; reading thermometer; use of ruler; changing from one unit to another; performing fundamental operations with denominate numbers; estimating quantities.

Concepts Involving Geometric Figures: recognizing kinds of geometric figures; perimeters and areas of plane figures; parts of a circle; angles and triangles; use of protractor and compass.

Concepts Involving Ratios and Proportion: ratio and proportion; scale drawing; equations.<sup>5</sup>

Arithmetic Problem Solving. Arithmetic problem solving was defined by the author of the "Iowa Tests of Basic Skills" in the Manual for Administrators, Supervisors, and Counselors in his explanation of Test A-2 concerning arithmetic problem solving as follows:

In the test on problem solving, competence is tested in a functional setting in problems which have been chosen to be challenging and practical. The fundamental operations and concepts involved in the problems for a particular grade are those generally presented prior to the first half of that grade in the most recently published textbook series in widespread use.

A conscious attempt was made to include in each test as many of the different number combinations as possible. Most frequently represented are those specific number skills which have consistently shown the highest incidence of error: higher decade facts, zero facts, . . . .<sup>6</sup>

#### Importance of the Problem

One of the most important problems faced by any classroom teacher has been the one of reteaching.

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<sup>5</sup>Manual for Administrators, Supervisors, and Counselors of The Iowa Tests of Basic Skills (Boston: Houghton Mifflin Company, 1955), pp. 69-70

<sup>6</sup>Ibid., p. 70.

The pupil needed to be provided with an opportunity to learn or relearn that which he has failed to learn, which he has only partially learned, which he has learned and forgotten, which he needs to learn more about, or which he needs to learn at a higher or more mature level.

Glennon wrote:

It seems important that the teacher distinguish between the program of practice (drill), the purpose of which is to fix skills which have already been learned, and the program of reteaching, the purpose of which is to provide the pupil with an opportunity to relearn through systematic, condensed re-teaching.

The experimental plan of reteaching, using a horizontal algorithm (illustrated in Chapter II) was evolved by the author for use at the beginning of each class period. Both the reteaching of fundamental processes and the equable distribution of short practice periods were essential to the development of arithmetical competency and the maintenance of skills. The experimental plan made it possible to practice several processes in one problem. The plan provided the benefits of immediate correction and individual help. A discussion of the problem and its solution provided

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Vincent J. Glennon, What Does Research Say About Arithmetic? Association for Supervision and Curriculum Development (Washington, D.C.: National Education Association, 1958), p. 45.

an opportunity to emphasize the concepts underlying the processes involved.

The experimental plan provided a means of challenging the more able child as well as giving encouragement and help to the less able child.

An evaluation of the experimental plan of reteaching to determine the value of this use of class time seemed to be desirable.

#### REVIEW OF LITERATURE

One of the important phases of any arithmetic program is the reteaching or review of the previous work. Research has been undertaken and suggestions have been made for improving this phase of the arithmetic program.

In recent years much emphasis has been placed upon meanings or understandings in arithmetic. Many authorities feel that any review or reteaching, to be really effective, must be done with better understanding of the meanings of arithmetic rather than as practice without understanding. Review of the literature and research related to this problem is presented to show the importance of reteaching.

Many phases of arithmetic need to be taught and re-taught several times at higher grade levels. Morton emphasized that children need additional opportunities to learn. He further indicated that what has been learned

can be learned more fully and at a more mature level. The plan of reteaching does not interfere with the effective teaching of new topics. It is important to make sure that the necessary fundamentals have been well learned and well understood.<sup>8</sup>

Morton gave a clear picture of the need for and the value of reteaching for understanding when he said:

Meaning is usually partial and incomplete at first; it becomes richer and fuller with later experiences. This is especially true if there is in each grade a reteaching program covering what has been "learned" in earlier grades . . . . We should reteach the meaning of numbers and the meaning of the process . . . . If we teach meaning fully, we realize that mere review is not enough but that reteaching is needed. What many pupils need is another chance to learn, and reteaching gives them that chance. If it is to be really meaningful, the reteaching will be a little different from the first or earlier reteaching. It will use different illustrations and possibly different approaches, and, at each grade level, it will be a little more mature than it was at earlier grade levels.<sup>9</sup>

Arthur, in a study, diagnosed the disabilities in arithmetic essentials of one hundred twenty-five high school freshmen. He emphasized the fact that basic concepts must be retaught at frequent intervals even in high school.

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<sup>8</sup>Robert L. Morton, Teaching Children Arithmetic (New York: Silver Burdett Company, 1953), p. 49.

<sup>9</sup>Robert L. Morton, "A New Look at Meaning," The Grade Teacher, April, 1956, p. 36.

He reported that:

Results of the test, in general, corroborate the fact that pupils have much greater difficulty in performing the fundamental operations with decimal fractions and with proper fractions than with integers. Pupils often performed on this test those operations dealing with whole numbers but worked incorrectly many problems which seemed to be of no greater difficulty except that they involved decimals and fractions.<sup>10</sup>

Arthur stated among other conclusions that:

It is reasonable to suppose that these basic concepts have been taught in the elementary school and many pupils either have failed to understand them in the first place or else have forgotten them. It is reasonable to suppose that these concepts will not be retained after the first reteaching in the high school. Since they must form part of the educational equipment of most graduates, they must be rechecked and retaught at frequent intervals.<sup>11</sup>

Morton stressed the importance of understanding when he stated: "It is a basic assumption that people do forget what they have learned and that they grow in their ability to understand ideas."<sup>12</sup>

Morton based much of his program in the teaching of arithmetic upon this philosophy for he stressed the importance of reteaching and placed much emphasis upon the expansion of understandings in the development of arith-

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<sup>10</sup>Lee E. Arthur, "Diagnosis of Disabilities in Arithmetic Essentials," The Mathematics Teacher, 43:197-202, May, 1950, p. 201.

<sup>11</sup>Ibid.

<sup>12</sup>Robert L. Morton, A Straight Talk to Teachers of Arithmetic (New York: Silver Burdett Company, 1954), p. 14.



metrical concepts.

The Joint Commission of the Mathematics Association of America and the National Council of Teachers of Mathematics have this to say in a section of their final report entitled "Essentials of a General Program in Secondary Mathematics:"

In all teaching of secondary mathematics much attention should be given to a conscious grasp of the principles which underlie the fundamental processes of arithmetic.<sup>13</sup>

Brownell defined "meaningful" arithmetic in contrast to "meaningless" arithmetic as "instruction which is deliberately planned to teach arithmetical meanings and to make arithmetic sensible to children through its mathematical relationships."<sup>14</sup>

Brownell suggested that the meanings of arithmetic can be grouped under four categories:

1. Basic concepts.
2. Fundamental operations
3. Important principles, relationships and generalizations of arithmetic
4. Understanding of decimal number system and its use in rationalizing our computational procedures and our algorithms.<sup>15</sup>

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<sup>13</sup>The Place of Mathematics in Secondary Education, Fifteenth Yearbook of National Council of Teachers of Mathematics (New York: Bureau of Publications, Teachers' College, Columbia University, 1940).

<sup>14</sup>William A. Brownell, "The Place of Meaning in the Teaching of Arithmetic." Elementary School Journal, 47: 256-265, p. 257.

<sup>15</sup>Ibid., p. 258.

Many informed opinions on the value of reteaching with understandings were found in the literature on the teaching of arithmetic. Brownell,<sup>16</sup> Brueckner and Grossnickle<sup>17</sup> and Banks<sup>18</sup> agreed that the pupil should develop the ability to perform the various number operations skillfully and with understanding.

Howard reported that the meaning method was more effective in establishing retention in the processes of computation as well as for the understanding of the principles of arithmetic.

The results of his study showed that "the meaning method was superior after the period of retention."<sup>19</sup>

The need to reteach to fix meanings and the use of practice to develop computational accuracy has received rather wide approval. Ludlow stated that

The modern concept, however, does definitely include purposeful practice to fix meanings and drill for computational accuracy and speed . . . Drill and practice now follow rather than precede understanding."<sup>20</sup>

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<sup>16</sup>Ibid., pp. 256-257.

<sup>17</sup>Leo J. Brueckner and Foster E. Grossnickle, How to Make Arithmetic Meaningful (Philadelphia: John C. Winston Company, 1947), p. 1.

<sup>18</sup>J. Houston Bank, Learning and Teaching Arithmetic (Boston: Allyn and Bacon, 1959), p. 11.

<sup>19</sup>Charles F. Howard, "Three Methods of Teaching Arithmetic," California Journal of Educational Research, 1:3-7, January, 1950, p. 7.

<sup>20</sup>H. G. Ludlow, "How to Get Meaning in Arithmetic," Education Digest, 21:37-39, February, 1956, p. 37.

Frazier and Burman agreed that reteaching and practice are necessary when they said that

Although children always learn better and remember longer if they fully understand what they are doing, forgetting is normal. For this reason, teaching, drill and reteaching are needed.<sup>21</sup>

Rappaport made a study to determine the degree of understandings of meanings in arithmetic. His investigation showed a discrepancy between computation skill and understanding of the basic meanings in arithmetic. He concluded that children need much practice to do accurate work but this should come after meanings have been developed and not before—in other words, meaningful practice instead of meaningless drill.<sup>22</sup>

There was wide agreement among many authorities that practice is necessary for the development and maintenance of skill in arithmetic. Morton,<sup>23</sup> Spencer and

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<sup>21</sup>Pauline Frazier and Marguerette Burman, "Arithmetic in Upper Elementary Grades," The Arithmetic Teacher, 6:165, April, 1959.

<sup>22</sup>David Rappaport, "An Investigation of the Degree of Understanding of Meaning in Arithmetic of Pupils in Selected Elementary Schools," Bulletin Number 8 of the U.S. Office of Education, 1960, p. 41.

<sup>23</sup>Robert L. Morton, "What Research Says to the Teacher," Teaching Arithmetic, Number 2, Department of Classroom Teachers of the American Educational Research Association of the National Education Association, 1953, p. 20.

Brydegaard,<sup>24</sup> and Fehr<sup>25</sup> were all of the opinion that practice periods, properly planned and well handled, serve necessary and important functions.

Marks, Purdy and Kinney spelled out in considerable detail certain principles essential to successful practice.

Repetitive practice needs expert guidance. The development of meaning does not remove the necessity for drill. . . . To place primary emphasis on meaning, then, does not preclude the use of practice, but merely changes its position in the learning sequence and to some extent its nature. The practice sessions are most effective if the teacher recognizes certain principles that have been established as essential to repetitive learning.

1. Understanding precedes drill . . . . .
2. Drill must be spaced . . . . . A smaller number of well-selected exercises, spaced in several, short, intensive practice sessions, is more efficient than one long session. . . . . At increasing intervals, the pupil should return to practice (and relearning of the underlying meanings).
3. Drill must be supervised. Drill activities must be planned so that the pupil will practice correct responses . . . . . Without proper guidance, many pupils will practice incorrect methods that will require considerable "unlearnings."
4. Activities must be varied. Variety increases the effectiveness of drill . . . . .
5. There is a need and purpose for drill.
6. Drill must be on the thinking, rational level.  
 . . . . . Less drill is required to fix skills when pupils have an understanding of the mathematical rationale.<sup>26</sup>

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<sup>24</sup>Peter L. Spencer and Marguerite N. Brydegaard, Building Mathematical Concepts in the Elementary School (New York: Henry Holt and Company, 1952), pp. 34-35.

<sup>25</sup>Howard F. Fehr, "A Philosophy of Arithmetic Instruction," The Arithmetic Teacher, 2:29, April, 1955, p. 29.

<sup>26</sup>John L. Marks, C. Richard Purdy and Lucien B. Kinney, Teaching Arithmetic for Understanding (New York: McGraw-Hill Book Company, 1958), pp. 26-27.

Knight, in a study made on distributed practice, reported that:

The material should be organized in small units so that it can be worked upon frequently.

A unit of drill material should possess examples calling for the use of many processes.

Mixed drills are preferable to materials using a single process.

Drill should have time limits, not for the purpose of developing unusual speeds but for the location of excessive slowness on the part of certain pupils, symptomatic of inadequate mastery of unit-skills involved.

Drill units should have standards of accuracy or performance.

Examples . . . should be arranged in order of difficulty.<sup>27</sup>

Butler and Wren<sup>28</sup> and Brueckner and Grossnickle<sup>29</sup> recommended rather short periods of practice, as short as ten minutes, and suggested that practice should be distributed in relatively small amounts at recurring intervals.

Morton advocated that in reteaching a new approach be used.<sup>30</sup> Swain suggested one approach as follows:

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<sup>27</sup>F. B. Knight, "The Superiority of Distributed Practice in Drill in Arithmetic," Journal of Educational Research, 15: 157-165, March, 1927, p. 158.

<sup>28</sup>Charles H. Butler and F. Lynwood Wren, The Teaching of Secondary Mathematics (New York: McGraw-Hill Book Company, 1960), p. 173.

<sup>29</sup>Op. cit., p. 114.

<sup>30</sup>Robert L. Morton, "A New Look at Meaning," The Grade Teacher, April, 1956, p. 36.

Pupils should be guided early toward expressing their work in equation form. The addition facts, for example, should be presented in vertical format and as an equation, such as  $5 + 7 = 12$ .<sup>31</sup>

A similar approach was used by The School Mathematics Study Group in "Junior High School Mathematics Units, Volume I, Number Systems," written for grade seven. A horizontal algorism is used in this text for most of the computational work.<sup>32</sup>

Although the literature and research have not revealed any one method of reteaching to be superior, there was evidence that the following factors are important in whatever method is used.

Reteaching involves learning at a higher and more mature level.

Understandings of the meanings of arithmetic should be emphasized.

Practice should be distributed at frequent intervals and over short periods of time.

The use of the horizontal algorism requires a more mature level of thinking.

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<sup>31</sup>Robert L. Swain, "Modern Mathematics and School Arithmetic" Twenty-fifth Yearbook of the National Council of Teachers of Mathematics (Washington, 1960), p. 276.

<sup>32</sup>School Mathematics Study Group, "Junior High School Mathematics Units, Volume I, Number Systems." (New Haven: Yale University, 1959).

A new approach to reteaching and relearning is valuable.

#### ORGANIZATION OF REMAINDER OF THESIS

Chapter II gives a description of the experimental plan used in the experiment, the statistical model used for the analysis of the data, the selection of matched pairs and the test used.

Chapter III presents the growth in arithmetic achievement of the experimental section as compared with the growth in achievement of the control section. The comparisons were made for the total group and also for each of three levels of ability, upper, middle and lower, with two areas of arithmetic achievement—concepts and problem solving. A survey of the test results was made in three areas of the test on arithmetic concepts.

Chapter IV gives the conclusions and interpretations of the study with suggestions for future related research.

## CHAPTER II

### THE EXPERIMENT

#### The Experimental Plan

The experimental plan of reteaching was based on (1) the use of the first part of the class period for systematic practice; and (2) the horizontal algorithm of computation in solving arithmetic problems. Before the beginning of the class period, a problem, (see Appendix for sample problems) to be solved with a horizontal algorithm, was placed on the blackboard. Each pupil worked to solve the problem for a period of not more than two or three minutes. The solution to the problem was presented, usually by a pupil. Alternate solutions with questions and discussion from the class were encouraged. The class time used by the plan varied from four to ten minutes.

The experimental plan was used four times a week over a period of twenty-two weeks. The plan presented many opportunities for the teacher to develop mathematical reasoning by stressing, when possible, understandings such as the following:

The variables  $a$ ,  $b$ ,  $c$ ,  $d$ ,  $x$ ,  $y$ , and  $z$  are non-negative integers and  $\neq 0$  when used as a divisor.



## 1. Multiplication or division by 1:

$$a \cdot 1 = a$$

$$\frac{a}{b} \cdot 1 = \frac{a}{b}$$

$$\frac{a}{1} = a$$

$$\frac{\frac{a}{b}}{1} = \frac{a}{b}$$

## 2. Multiplication or division by a number larger than 1:

If  $b > 1$   
 then  $a \cdot b > a$   
 and  $\frac{a}{b} < a$

or

If  $\frac{c}{d} > 1$   
 then  $\frac{a}{b} \cdot \frac{c}{d} > \frac{a}{b}$   
 and  $\frac{\frac{a}{b}}{\frac{c}{d}} < \frac{a}{b}$

## 3. Multiplication or division by a number smaller than 1:

If  $b < 1$   
 then  $a \cdot b < a$   
 and  $\frac{a}{b} > a$

or

If  $\frac{c}{d} < 1$   
 then  $\frac{a}{b} \cdot \frac{c}{d} < \frac{a}{b}$   
 and  $\frac{\frac{a}{b}}{\frac{c}{d}} > \frac{a}{b}$

## 4. Multiplication of a fraction without changing the value of the fraction:

$$\frac{a}{b} = \frac{a}{b} \cdot 1 = \frac{a}{b} \cdot \frac{c}{c} = \frac{ac}{bc}$$

5. The location and use of the decimal point:  
 the decimal point indicates the units digit.

6. Multiplication of a number by 10 or a multiple

of 10:

$$.4 \times 10 = 4 \qquad .4 \times 100 = 40$$

7. Division of a number by 10 or a multiple of

10:

$$.4 \div 10 = .04 \qquad .4 \div 100 = .004$$

8. Division by a fraction using its reciprocal:

$$a \div \frac{c}{d} = a \cdot \frac{d}{c} = \frac{ad}{c} \quad \text{or} \quad \frac{a}{\frac{c}{d}} = \frac{a \cdot \frac{d}{c}}{\frac{c}{d} \cdot \frac{d}{c}} = \frac{\frac{ad}{c}}{1} = \frac{ad}{c}$$

$$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c} = \frac{ad}{bc} \quad \text{or} \quad \frac{\frac{a}{b}}{\frac{c}{d}} = \frac{\frac{a}{b} \cdot \frac{d}{c}}{\frac{c}{d} \cdot \frac{d}{c}} = \frac{\frac{ad}{bc}}{1} = \frac{ad}{bc}$$

9. Division by a fraction using the lowest common

multiple (L.C.M.):

$$\frac{a}{\frac{c}{d}} = \frac{a \cdot d}{\frac{c}{d} \cdot d} = \frac{ad}{c}$$

or

$$\frac{\frac{a}{b}}{\frac{c}{d}} = \frac{\frac{a}{b} \cdot x}{\frac{c}{d} \cdot x} = \frac{y}{z}$$

where

x is the L.C.M. of b and d

and

$$\frac{a}{b} \cdot x = y$$

$$\frac{c}{d} \cdot x = z$$

10. Meaning and use of the exponent:

$$a^b = a \cdot a \cdot a \dots a$$

where

b = number of factors.

11. Understanding of the meaning and use of the equal sign. Use "=" only to express equivalents.

The procedure used in solving a problem together with the horizontal algorithm was as follows:

1. The problem was written on the blackboard.

$$(3.2 \div 100) + (6.4 \times 10) =$$

2. The pupil worked for not more than three minutes.

3. The solution was pupil presented with the horizontal algorithm.

$$(3.2 \div 100) + (6.4 \times 10) =$$

$$.032 + 6.4 =$$

6.432 Answer.

4. The discussion with questions followed.
5. Understandings, such as listed on pages 17 - 20, involved in the solving of the problem were emphasized.
6. Processes used in the above decimal problem were:
- division by a power of 10
  - multiplication by a power of 10
  - division of a number in decimal form
  - multiplication of a number in decimal form

e. addition of numbers in decimal form.

Problem Involving Whole Numbers with Horizontal

Algorithm:

$$4(2 + 3) + 35 \div 5 =$$

$$4(5) + 7 =$$

$$20 + 7 =$$

$$27 \quad \text{Answer}$$

Problem Involving Numbers in Fraction Form with

Horizontal Algorithm:

$$\frac{2\frac{1}{2}}{\quad} \times \frac{2}{5} =$$

$$\frac{5\frac{1}{3}}{\quad} \times \frac{3}{4}$$

$$\frac{\frac{5}{2}}{\frac{16}{3}} \times \frac{\frac{2}{5}}{\frac{3}{4}} =$$

$$\frac{\frac{1}{1}}{\frac{4}{1}} =$$

$$\frac{1}{4} \quad \text{Answer}$$

The experimental plan was used with an experimental section but not with a control section (see page 23). Both sections were taught the same number of class periods, used the same textbook, followed the same curriculum guide, and had the same number of homework assignments per week. The teacher of the control section and the author, who taught

the experimental section, were in frequent conferences to eliminate as far as possible the teacher variable. The only apparent variable was the use of the experimental plan with the experimental section.

### The Statistical Model

Matched pairs were selected to form the groups used in the study. The difference of the means was calculated to determine if the t ratio of difference was significant at the 5 per cent level from zero.

Formulas used to determine the t ratio were from Elementary Statistics by Garrett.<sup>1</sup>

1. Means were computed by:  $\frac{\sum fx}{N}$  .<sup>2</sup>

$\sum fx$  = sum of frequency times score  
N = number of cases

2. Standard deviations were computed by:  $\sqrt{\frac{\sum d^2}{N-1}}$  .<sup>3</sup>

$\sum d^2$  = sum of deviations squared  
N-1 = number of cases minus 1

3. Standard error of means were computed by:  $\frac{SD}{\sqrt{N-1}}$  .<sup>4</sup>

SD = standard deviation  
N-1 = number of cases minus 1

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<sup>1</sup>Henry E. Garrett, Elementary Statistics (New York: Longman, Green and Company, 1956).

<sup>2</sup>Ibid., p. 30.

<sup>3</sup>Ibid., p. 91.

<sup>4</sup>Ibid.

4. Standard error of the differences was computed

by:

$$\sqrt{(SE_{m_1})^2 + (SE_{m_2})^2} .^5$$

$SE_{m_1}$  = standard error of mean for  
experimental section

$SE_{m_2}$  = standard error of mean for  
control section

5. Critical ratios or t ratios were computed by:

$$\frac{dm}{SE_d} .^6$$

$dm$  = difference of the means

$SE_d$  = standard error of the difference

#### Selection of Groups

The study compared the gain by seventh grade pupils in two areas of arithmetic achievement.

Group A-1, composed of thirty matched pairs was compared on achievement in the area of arithmetic concepts. The pairs selected for Group A-1 were matched for intelligence quotient as determined by the score made on the "California Test of Mental Maturity" given in October, 1959, and for their arithmetic concept scores as determined by the "Iowa Tests of Basic Skills" given in June, 1960. The grade six test scores on the arithmetic problem solving

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<sup>5</sup>Ibid., p. 96.

<sup>6</sup>Ibid.

test were used to test the null hypothesis that the experimental section would not differ from the control section on arithmetic solving ability. It was found that the mean difference of the arithmetic problem solving scores for the thirty matched pairs of Group A-1 was a negative .57 and that the t ratio for the difference of the two sections on problem solving ability was a negative .06 which was not statistically significant at the 5 per cent level.

The pairs selected for Group A-2 were matched for intelligence quotient as determined by the scores made on the "California Test of Mental Maturity" given in October, 1959, and for their arithmetic problem solving scores as determined by the "Iowa Tests of Basic Skills" given in June, 1960. The grade six test scores on the arithmetic concepts test were used to test the null hypothesis that the experimental section would not differ from the control section on arithmetic concepts ability. It was found that the mean difference of the arithmetic concepts scores for the thirty matched pairs of Group A-2 was 1.3 and that the t ratio for the difference of the two sections on concepts ability was 1.8 which was not significant at the 5 per cent level.

The range of the intelligence quotient scores for the matched pairs in Group A-1 and Group A-2 was from a

low of 94 to a high of 132.

The intelligence quotient scores were matched within three points and the arithmetic concept scores for Group A-1 and the problem solving scores for Group A-2 were matched within two points. Both of the groups were subdivided into three levels of mental ability: at the upper level with intelligence quotient of 120 or above; at the middle level with intelligence quotient of 110 to 119; and at the lower level with intelligence quotient of 109 or below. It was assumed that the "forgetting" factor for the summer vacation between the 1960 test and the 1961 test was the same for the experimental section and for the control section.

The code used in the Tables to identify the matched pairs is a four place numeral such as 1101 and 1201. The left digit refers to the group: "1" for Group A-1 and "2" for Group A-2. The second digit from the left refers to the matched pair with the digit 1 representing the experimental group and the digit 2 representing the control group. The digits on the right refer to the pupil in the section and are listed in consecutive order from 1 to 30. For example, reading from right to left, the numeral 1204 indicates the number four member of the control section of Group A-1.



Table I lists the matched pairs for Group A-1, the code numbers, the intelligence quotient scores, the grade level scores on the arithmetic concepts test for 1960, and the percentile norms. The range of intelligence quotient scores for Group A-1 was from a low of 95 to a high of 125. The range of grade level scores on the arithmetic concepts test was from a low of 57 to a high of 94.

The grade equivalent matched with a given raw score on any test indicated the grade level at which the typical pupil made this raw score. A normal or average year's growth is ten points. The right hand digit represents the months within the grade, and the digits to the left of the right hand digit represent the grade at which a typical pupil made a corresponding raw score.

For example, if a pupil made a grade equivalent of 74, this means that his raw score on the test was the same as that made by the typical pupil in the seventh grade at the end of the fourth month in that grade.<sup>7</sup>

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<sup>7</sup>Teacher's Manual, Iowa Tests of Basic Skills  
(Boston: Houghton Mifflin Company, 1955), p. 18.

TABLE I

MATCHED PAIRS SELECTED FOR GROUP A-1 SHOWING  
INTELLIGENCE QUOTIENT SCORES, GRADE SIX  
TEST SCORES, AND NATIONAL  
PERCENTILE RANK

| EXPERIMENTAL   |      |                        |              | CONTROL        |      |                        |              |
|----------------|------|------------------------|--------------|----------------|------|------------------------|--------------|
| Code<br>Number | I.Q. | Grade<br>Level<br>1960 | File<br>norm | Code<br>Number | I.Q. | Grade<br>Level<br>1960 | File<br>norm |
| 1101           | 125  | 76                     | 81           | 1201           | 124  | 75                     | 77           |
| 1102           | 124  | 83                     | 94           | 1202           | 124  | 81                     | 91           |
| 1103           | 123  | 80                     | 90           | 1203           | 123  | 78                     | 86           |
| 1104           | 123  | 80                     | 90           | 1204           | 123  | 79                     | 88           |
| 1105           | 122  | 79                     | 88           | 1205           | 121  | 80                     | 90           |
| 1106           | 121  | 71                     | 81           | 1206           | 123  | 72                     | 65           |
| 1107           | 120  | 81                     | 91           | 1207           | 122  | 83                     | 94           |
| 1108           | 119  | 85                     | 96           | 1208           | 117  | 85                     | 96           |
| 1109           | 117  | 85                     | 96           | 1209           | 118  | 86                     | 97           |
| 1110           | 116  | 79                     | 88           | 1210           | 118  | 76                     | 81           |
| 1111           | 116  | 73                     | 70           | 1211           | 116  | 72                     | 65           |
| 1112           | 116  | 75                     | 77           | 1212           | 114  | 76                     | 81           |
| 1113           | 115  | 80                     | 90           | 1213           | 118  | 79                     | 88           |
| 1114           | 115  | 69                     | 54           | 1214           | 115  | 68                     | 50           |
| 1115           | 115  | 73                     | 70           | 1215           | 115  | 74                     | 74           |
| 1116           | 114  | 79                     | 88           | 1216           | 114  | 78                     | 86           |
| 1117           | 113  | 86                     | 97           | 1217           | 114  | 88                     | 99           |
| 1118           | 112  | 72                     | 65           | 1218           | 111  | 74                     | 74           |
| 1119           | 110  | 75                     | 77           | 1219           | 110  | 75                     | 76           |
| 1120           | 110  | 80                     | 90           | 1220           | 111  | 78                     | 86           |
| 1121           | 110  | 76                     | 81           | 1221           | 109  | 75                     | 77           |
| 1122           | 109  | 69                     | 54           | 1222           | 112  | 67                     | 47           |
| 1123           | 108  | 70                     | 58           | 1223           | 109  | 71                     | 62           |
| 1124           | 107  | 72                     | 65           | 1224           | 106  | 74                     | 74           |
| 1125           | 105  | 70                     | 58           | 1225           | 104  | 72                     | 65           |
| 1126           | 103  | 70                     | 58           | 1226           | 101  | 71                     | 62           |
| 1127           | 103  | 64                     | 37           | 1227           | 100  | 66                     | 43           |
| 1128           | 102  | 80                     | 90           | 1228           | 103  | 80                     | 90           |
| 1129           | 98   | 75                     | 77           | 1229           | 98   | 75                     | 77           |
| 1130           | 96   | 62                     | 30           | 1230           | 95   | 64                     | 37           |

Table II lists the matched pairs selected for Group A-2, the code numbers, the intelligence quotient scores, the grade level scores on the arithmetic problem solving test for 1960, and the percentile norms. The range of intelligence quotient scores for Group A-2 was from a low of 94 to a high of 132. The range of the grade level scores on the arithmetic problem solving test was from a low of 62 to a high of 88.

TABLE II

MATCHED PAIRS SELECTED FOR GROUP A-2 SHOWING  
INTELLIGENCE QUOTIENT SCORES, GRADE SIX  
TEST SCORES, AND NATIONAL  
PERCENTILE RANK

| EXPERIMENTAL   |      |                        |               | CONTROL        |      |                        |               |
|----------------|------|------------------------|---------------|----------------|------|------------------------|---------------|
| Code<br>Number | I.Q. | Grade<br>Level<br>1960 | %-ile<br>norm | Code<br>Number | I.Q. | Grade<br>Level<br>1960 | %-ile<br>norm |
| 2101           | 132  | 70                     | 59            | 2201           | 129  | 72                     | 67            |
| 2102           | 125  | 69                     | 55            | 2202           | 124  | 67                     | 46            |
| 2103           | 123  | 70                     | 59            | 2203           | 123  | 67                     | 46            |
| 2104           | 122  | 85                     | 95            | 2204           | 123  | 82                     | 91            |
| 2105           | 122  | 82                     | 91            | 2205           | 122  | 82                     | 91            |
| 2106           | 122  | 76                     | 80            | 2206           | 121  | 76                     | 80            |
| 2107           | 121  | 70                     | 59            | 2207           | 120  | 72                     | 67            |
| 2108           | 120  | 88                     | 97            | 2208           | 119  | 88                     | 97            |
| 2109           | 120  | 78                     | 85            | 2209           | 118  | 80                     | 89            |
| 2110           | 119  | 94                     | 99            | 2210           | 118  | 94                     | 99            |
| 2111           | 117  | 74                     | 74            | 2211           | 114  | 76                     | 80            |
| 2112           | 116  | 88                     | 97            | 2212           | 116  | 88                     | 97            |
| 2113           | 116  | 91                     | 99            | 2213           | 114  | 91                     | 99            |
| 2114           | 116  | 78                     | 85            | 2214           | 114  | 80                     | 89            |
| 2115           | 116  | 72                     | 67            | 2215           | 116  | 69                     | 55            |
| 2116           | 115  | 80                     | 89            | 2216           | 118  | 80                     | 89            |
| 2117           | 115  | 72                     | 67            | 2217           | 115  | 72                     | 67            |
| 2118           | 114  | 91                     | 99            | 2218           | 114  | 91                     | 99            |
| 2119           | 113  | 85                     | 95            | 2219           | 114  | 88                     | 97            |
| 2120           | 112  | 69                     | 55            | 2220           | 111  | 69                     | 55            |
| 2121           | 110  | 78                     | 85            | 2221           | 110  | 76                     | 80            |
| 2122           | 110  | 80                     | 89            | 2222           | 107  | 82                     | 91            |
| 2123           | 108  | 63                     | 31            | 2223           | 109  | 66                     | 42            |
| 2124           | 107  | 57                     | 12            | 2224           | 106  | 57                     | 12            |
| 2125           | 107  | 78                     | 85            | 2225           | 108  | 76                     | 80            |
| 2126           | 107  | 64                     | 35            | 2226           | 109  | 67                     | 46            |
| 2127           | 105  | 64                     | 35            | 2227           | 104  | 67                     | 46            |
| 2128           | 103  | 67                     | 46            | 2228           | 100  | 67                     | 46            |
| 2129           | 96   | 61                     | 24            | 2229           | 99   | 63                     | 31            |
| 2130           | 94   | 74                     | 74            | 2230           | 94   | 76                     | 80            |

The Test and Its Administration

The test used for the selection of pupils for this study was the "Iowa Tests of Basic Skills, Form 1."<sup>8</sup> The parts used were: Section A-1, "Arithmetic Concepts" and Section A-2, "Arithmetic Problem Solving."<sup>9</sup> The definitions of arithmetic concepts and arithmetic problem solving as used by this test are given in the section under definitions in Chapter I. This test was given in June, 1960, at the completion of grade six. From this test were taken the grade six scores used in selection of matched pairs for Group A-1 and Group A-2 used in this study.

Two parts of the "Iowa Tests of Basic Skills, Form 1" for grade seven were administered at the conclusion of the experiment. Section A-1, "Arithmetic Concepts", and Section A-2, "Arithmetic Problem Solving", were given to all members of the experimental group and of the control group on March 31 and on April 1, 1961. All tests were administered by experienced supervisors. The 1960 and 1961 test papers were hand scored as instructed in the "Manual of the Iowa Tests of Basic Skills."<sup>10</sup>

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<sup>8</sup>Iowa Tests of Basic Skills, Form 1 (Boston: Houghton Mifflin Company, 1955), pp. 82-85.

<sup>9</sup>Ibid., pp. 92-94.

<sup>10</sup>Teacher's Manual, Iowa Tests of Basic Skills (Boston: Houghton Mifflin Company, 1955), p. 16.

Following the experiment, the arithmetic achievement scores of the "Iowa Tests of Basic Skills", 1961, were compared with the arithmetic achievement scores of the "Iowa Tests of Basic Skills" of 1960 by using the t test at the 5 per cent level.

#### Limitations of the Study

There were a number of limitations in the carrying out of the study.

The size of the group limited the number of matched pairs available for the study. It would have improved the study to have been able to use the same matched pairs for Group A-1 and Group A-2.

It was not possible to control the element of "summer forgetting" in the groups. The tests used were those made available by the school system and given at their direction or by their permission. The element of "summer forgetting" was assumed to be the same for the members of Group A-1 and Group A-2.

In addition, the standardized test selected for use was not specifically designed to evaluate the results of the experiment. The test used, however, was the one adopted by the school system and the test results did provide a basis for comparisons between the experimental group and the control group.

The number of teachers in the study was a limiting factor. It would have been desirable to have had a larger number of teachers and to have had each teacher teach one group by the experimental plan and another group as a control (without the experimental plan). Considerable care was taken to keep the curriculum, homework assignments, and time spent on each topic uniform in order to eliminate the teacher variable.

## CHAPTER III

### ANALYSIS OF DATA

Chapter III presents the statistics and an analysis of the growth in arithmetic achievement of the experimental group as compared with the growth in arithmetic achievement of the control group. The comparisons were made on each of three levels of ability, designated as upper, middle and lower level, with two areas of arithmetic achievement-- concepts and problem solving.

The results of an analysis of skills, for Group A-1, for those areas on the arithmetic concepts test involving whole numbers, fractions and decimals are also presented in this chapter.

#### Analysis of Arithmetic Achievement on Concepts for Group A-1

Table III shows the positive (+) and negative (-) gains by months, in arithmetic concepts, for each member of the matched pairs in Group A-1. These were computed by comparing the grade level scores from Table I and Table III. Also listed are the matched pairs, by code number, the intelligence quotients and the grade level scores for 1961.

In the left column, the ability groups used in the



study are identified as upper, middle and lower levels. This is for further analysis in this chapter. The upper level was comprised of those students with an intelligence quotient of 120 or above. The middle level was comprised of those students with an intelligence quotient of 110--119. The lower level was comprised of those students with an intelligence quotient of 109 and below.

The mean gain for the experimental section was 8.2 months. The gain for the control section was 7.8 months. The difference in mean gain for Group A-1 was .4 months. On taking the null hypothesis that the experimental section would not differ from the control section on the arithmetic concepts test, it was found that the t ratio for the difference of gain was .06 which is not statistically significant at the 5 per cent level.

TABLE III

ABILITY LEVELS SELECTED FOR GROUP A-1 SHOWING  
INTELLIGENCE QUOTIENT SCORES, GRADE SEVEN  
TEST SCORES, AND GAINS IN  
ARITHMETIC CONCEPTS

| EXPERIMENTAL               |                |      |                        |                    | CONTROL        |      |                        |                    |
|----------------------------|----------------|------|------------------------|--------------------|----------------|------|------------------------|--------------------|
|                            | Code<br>Number | I.Q. | Grade<br>Level<br>1961 | Gain<br>in<br>Mos. | Code<br>Number | I.Q. | Grade<br>Level<br>1961 | Gain<br>in<br>Mos. |
| UPPER<br>LEVEL             | 1101           | 125  | 91                     | 16                 | 1201           | 124  | 79                     | 4                  |
|                            | 1102           | 124  | 97                     | 14                 | 1202           | 124  | 89                     | 8                  |
|                            | 1103           | 123  | 95                     | 15                 | 1203           | 123  | 89                     | 11                 |
|                            | 1104           | 123  | 87                     | 7                  | 1204           | 123  | 86                     | 7                  |
|                            | 1105           | 122  | 87                     | 8                  | 1205           | 121  | 81                     | 1                  |
|                            | 1106           | 121  | 86                     | 15                 | 1206           | 123  | 97                     | 15                 |
|                            | 1107           | 120  | 88                     | 7                  | 1207           | 122  | 94                     | 11                 |
|                            | 1108           | 119  | 92                     | 7                  | 1208           | 117  | 92                     | 7                  |
|                            | 1109           | 117  | 83                     | - 2                | 1209           | 118  | 90                     | 4                  |
|                            | 1110           | 116  | 95                     | 16                 | 1210           | 118  | 87                     | 11                 |
| MIDDLE<br>LEVEL            | 1111           | 116  | 81                     | 8                  | 1211           | 116  | 84                     | 12                 |
|                            | 1112           | 116  | 72                     | - 3                | 1212           | 114  | 85                     | 9                  |
|                            | 1113           | 115  | 92                     | 12                 | 1213           | 118  | 89                     | 10                 |
|                            | 1114           | 115  | 66                     | - 3                | 1214           | 115  | 78                     | 10                 |
|                            | 1115           | 115  | 87                     | 14                 | 1215           | 115  | 92                     | 18                 |
|                            | 1116           | 114  | 82                     | 3                  | 1216           | 114  | 82                     | 4                  |
|                            | 1117           | 113  | 83                     | - 3                | 1217           | 114  | 92                     | 4                  |
|                            | 1118           | 112  | 83                     | 11                 | 1218           | 111  | 84                     | 10                 |
|                            | 1119           | 110  | 84                     | 9                  | 1219           | 110  | 78                     | 3                  |
|                            | 1120           | 110  | 83                     | 3                  | 1220           | 111  | 87                     | 9                  |
| LOWER<br>LEVEL             | 1121           | 110  | 90                     | 14                 | 1221           | 109  | 86                     | 11                 |
|                            | 1122           | 109  | 75                     | 6                  | 1222           | 112  | 81                     | 14                 |
|                            | 1123           | 108  | 77                     | 7                  | 1223           | 109  | 78                     | 7                  |
|                            | 1124           | 107  | 76                     | 4                  | 1224           | 106  | 77                     | 3                  |
|                            | 1125           | 105  | 85                     | 15                 | 1225           | 104  | 77                     | 5                  |
|                            | 1126           | 103  | 82                     | 12                 | 1226           | 101  | 70                     | - 1                |
|                            | 1127           | 103  | 74                     | 10                 | 1227           | 100  | 75                     | 9                  |
|                            | 1128           | 102  | 86                     | 6                  | 1228           | 103  | 90                     | 10                 |
|                            | 1129           | 98   | 78                     | 3                  | 1229           | 98   | 77                     | 2                  |
|                            | 1130           | 96   | 78                     | 16                 | 1230           | 95   | 91                     | 7                  |
| Mean<br>Gain<br>in<br>Mos. |                |      |                        | 8.2<br>mos.        |                |      |                        | 7.8<br>mos.        |

Analysis of Arithmetic Achievement on Problem Solving  
for Group A-2

Table IV shows the positive (+) and negative (-) gains in months, in arithmetic problem solving, for each member of the matched pairs in Group A-2. These were computed by comparing the grade level scores from Table II and Table IV. Also listed are the matched pairs, by code number, the intelligence quotients and the grade level scores for 1961.

In the left column, the ability groups used in the study are identified as upper, middle and lower levels. This was for further analysis in this chapter. The upper level was comprised of those students with an intelligence quotient of 120 or above. The middle level was comprised of those students with an intelligence quotient of 110--119. The lower level was comprised of those students with an intelligence quotient of 109 or below.

The mean gain for the experimental section was 6.5 months. The mean gain for the control section was 3.9 months. The difference in mean gain for Group A-2 was 2.6 months. On taking the null hypothesis that the experimental section would not differ from the control section on the arithmetic problem solving test, it was found that the t ratio for the difference of gain was .25 which is not statistically significant at the 5 per cent level.

TABLE IV

ABILITY LEVELS SELECTED FOR GROUP A-2 SHOWING  
INTELLIGENCE QUOTIENT SCORES, GRADE SEVEN  
TEST SCORES, AND GAINS IN ARITHMETIC  
PROBLEM SOLVING

| EXPERIMENTAL               |                |      |                        |                    | CONTROL        |      |                        |                    |
|----------------------------|----------------|------|------------------------|--------------------|----------------|------|------------------------|--------------------|
|                            | Code<br>Number | I.Q. | Grade<br>Level<br>1961 | Gain<br>in<br>Mos. | Code<br>Number | I.Q. | Grade<br>Level<br>1961 | Gain<br>in<br>Mos. |
| UPPER<br>LEVEL             | 2101           | 132  | 85                     | 13                 | 2201           | 129  | 81                     | 9                  |
|                            | 2102           | 125  | 75                     | 6                  | 2202           | 124  | 75                     | 8                  |
|                            | 2103           | 123  | 85                     | 15                 | 2203           | 123  | 97                     | 20                 |
|                            | 2104           | 122  | 85                     | 0                  | 2204           | 123  | 88                     | 6                  |
|                            | 2105           | 122  | 86                     | 4                  | 2205           | 122  | 85                     | 3                  |
|                            | 2106           | 122  | 81                     | 4                  | 2206           | 121  | 79                     | 3                  |
|                            | 2107           | 121  | 79                     | 9                  | 2207           | 120  | 79                     | 7                  |
|                            | 2108           | 120  | 97                     | 9                  | 2208           | 119  | 79                     | - 9                |
|                            | 2109           | 120  | 95                     | 17                 | 2209           | 118  | 81                     | 1                  |
|                            | 2110           | 119  | 93                     | - 1                | 2210           | 118  | 97                     | 3                  |
| MIDDLE<br>LEVEL            | 2111           | 117  | 75                     | 1                  | 2211           | 114  | 88                     | 12                 |
|                            | 2112           | 116  | 73                     | -15                | 2212           | 116  | 85                     | - 3                |
|                            | 2113           | 116  | 95                     | 4                  | 2213           | 114  | 81                     | -10                |
|                            | 2114           | 116  | 85                     | 7                  | 2214           | 114  | 93                     | 13                 |
|                            | 2115           | 116  | 79                     | 7                  | 2215           | 116  | 81                     | 12                 |
|                            | 2116           | 115  | 83                     | 3                  | 2216           | 118  | 79                     | - 1                |
|                            | 2117           | 115  | 81                     | 9                  | 2217           | 115  | 64                     | - 8                |
|                            | 2118           | 114  | 88                     | 3                  | 2218           | 114  | 89                     | - 2                |
|                            | 2119           | 113  | 77                     | 8                  | 2219           | 114  | 91                     | 3                  |
|                            | 2120           | 112  | 66                     | 3                  | 2220           | 111  | 84                     | 15                 |
| LOWER<br>LEVEL             | 2121           | 110  | 83                     | 5                  | 2221           | 110  | 83                     | 7                  |
|                            | 2122           | 110  | 89                     | 9                  | 2222           | 107  | 81                     | - 1                |
|                            | 2123           | 108  | 79                     | 16                 | 2223           | 109  | 77                     | 11                 |
|                            | 2124           | 107  | 77                     | 20                 | 2224           | 106  | 53                     | - 4                |
|                            | 2125           | 107  | 89                     | 11                 | 2225           | 108  | 79                     | 3                  |
|                            | 2126           | 107  | 69                     | 5                  | 2226           | 109  | 79                     | 12                 |
|                            | 2127           | 105  | 75                     | 11                 | 2227           | 104  | 69                     | 2                  |
|                            | 2128           | 103  | 83                     | 16                 | 2228           | 100  | 64                     | - 3                |
|                            | 2129           | 96   | 75                     | 14                 | 2229           | 99   | 66                     | 3                  |
|                            | 2130           | 94   | 83                     | 9                  | 2230           | 94   | 79                     | 4                  |
| Mean<br>Gain<br>in<br>Mos. |                |      |                        | 6.5<br>mos.        |                |      |                        | 3.9<br>mos.        |

Analysis of Arithmetic Achievement on Concepts for  
Group A-1 by Ability Groups

Table V presents the mean gains, differences of mean gains, standard error of the difference, and t ratio of the upper, middle and lower levels of the experimental and control sections of Group A-1.

The statistical analysis shows a t ratio of 1.33 for the upper level comprised of pupils with intelligence quotients of 120 or above, which is not statistically significant (N.S.) at the 5 per cent level. The t ratio for the middle level, comprised of pupils with intelligence quotients of 110--119, is a negative 1.02, which is not statistically significant at the 5 per cent level. The t ratio for the lower level, comprised of pupils with intelligence quotients of 109 or below, is 1.04, which is not statistically significant at the 5 per cent level.

TABLE V

MEAN GAINS, DIFFERENCES OF MEAN GAINS, STANDARD ERROR OF THE DIFFERENCE, AND t RATIO FOR THE DIFFERENCE OF THE MEANS OF THE UPPER, MIDDLE AND LOWER LEVELS OF THE EXPERIMENTAL AND CONTROL SECTIONS OF GROUP A-1 BASED ON "IOWA ARITHMETIC CONCEPTS TEST" GIVEN IN JUNE, 1960 AND APRIL, 1961

| Group A-1    | Mean Gain of Experimental Section | Mean Gain of Control Section | Diff. of Mean Gains | Standard Error Of The Diff. | t Ratio | Level of Significance |
|--------------|-----------------------------------|------------------------------|---------------------|-----------------------------|---------|-----------------------|
| UPPER LEVEL  | 11.71                             | 8.14                         | 3.57                | 2.69                        | 1.33    | N.S.*                 |
| MIDDLE LEVEL | 6.14                              | 8.71                         | -2.57               | 2.52                        | -1.02   | N.S.                  |
| LOWER LEVEL  | 8.77                              | 6.22                         | 2.55                | 2.45                        | 1.04    | N.S.                  |

\*Not significant at the .05 level.

Analysis of Arithmetic Achievement on Problem Solving  
for Group A-2 by Ability Groups

Table VI presents the mean gain, differences of mean gains, standard error of the difference, and t ratio of the upper, middle and lower levels of the experimental and control sections of Group A-2.

The statistical analysis shows a t ratio of .94 for the upper level, comprised of pupils with intelligence quotients of 120 or above, which is not statistically significant at the 5 per cent level. The t ratio for the middle level, comprised of pupils with intelligence quotients of 110--119 is a negative .62 which is not statistically significant at the 5 per cent level. The t ratio for the lower level, comprised of pupils with intelligence quotients of 109 or below, is 3.19, which is statistically significant at the 5 per cent level and also at the 2 per cent level.

TABLE VI

MEAN GAINS, DIFFERENCES OF MEAN GAINS, STANDARD ERROR OF THE DIFFERENCE, AND t RATIO FOR THE DIFFERENCE OF THE MEANS OF THE UPPER, MIDDLE AND LOWER LEVELS OF THE EXPERIMENTAL AND CONTROL SECTIONS OF GROUP A-2 BASED ON "IOWA ARITHMETIC PROBLEM SOLVING TEST" GIVEN IN JUNE, 1960 AND APRIL, 1961

| Group<br>A-2    | Mean<br>Gain of<br>Experi-<br>mental<br>Section | Mean<br>Gain<br>of<br>Control<br>Section | Diff.<br>of<br>Mean<br>Gains | Standard<br>Error<br>Of The<br>Diff. | t<br>Ratio | Level<br>of<br>Signifi-<br>cance |
|-----------------|---|--|------------------------------|--------------------------------------|------------|----------------------------------|
| UPPER<br>LEVEL  | 8.55  | 5.33                                     | 3.22                         | 3.42                                 | .94        | N.S.*                            |
| MIDDLE<br>LEVEL | 1.15  | 3.08                                     | 1.93                         | 3.09                                 | .62        | N.S.                             |
| LOWER<br>LEVEL  | 12.75   | 3.50                                     | 9.25                         | 2.90                                 | 3.19       | .02                              |

\*Not significant at the .05 level.



Survey of Skills on Arithmetic Concepts for Group A-1

Table VII presents the results of a survey made for Group A-1, at three ability levels, on the arithmetic concepts of the skills involving whole numbers, fractions and decimals as designated in the "Teacher's Manual of the Iowa Tests of Basic Skills."<sup>1</sup>

The per cent of items answered correctly was found for the experimental section and the control section at three ability levels. In the area of whole numbers, the experimental section showed a higher per cent of items correct. The upper level of the experimental section had ninety per cent of fraction items correct compared with eighty-one per cent correct for the control section. The lower level of the experimental section had sixty-seven per cent decimal items correct compared with fifty-six per cent for the control section. In the remaining sections of the test, the control section did a little better than the experimental group.

A t ratio for the upper level of Group A-1 on the section of the test involving skill in fractions was found to be 1.125. This was not significant at the 5 per cent level, so no t ratio was found for any other section of the survey of skills.

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<sup>1</sup>Teacher's Manual, Iowa Tests of Basic Skills  
(Boston. Houghton Mifflin Company, 1955), pp. 36-37.

TABLE VII

SURVEY OF SKILLS FOR GROUP A-1 AT THREE ABILITY LEVELS  
IN THE ARITHMETIC CONCEPTS TEST INVOLVING  
WHOLE NUMBERS, FRACTIONS AND DECIMALS

| GROUP A-1       |                        | EXPERIMENTAL     |                 |          |         | CONTROL |                 |          |         |       |
|-----------------|------------------------|------------------|-----------------|----------|---------|---------|-----------------|----------|---------|-------|
|                 | Number<br>of<br>Pupils | Items<br>Correct | Whole<br>Number | Fraction | Decimal | Total   | Whole<br>Number | Fraction | Decimal | Total |
| UPPER<br>LEVEL  | 7                      | NO.              | 21              | 76       | 40      | 137     | 19              | 68       | 42      | 129   |
|                 |                        | PER<br>CENT      | 100             | 90       | 71      | 85      | 90              | 81       | 75      | 80    |
| MIDDLE<br>LEVEL | 14                     | NO.              | 37              | 123      | 78      | 238     | 36              | 130      | 82      | 248   |
|                 |                        | PER<br>CENT      | 88              | 73       | 69      | 74      | 86              | 77       | 73      | 77    |
| LOWER<br>LEVEL  | 9                      | NO.              | 26              | 56       | 48      | 130     | 22              | 59       | 40      | 121   |
|                 |                        | PER<br>CENT      | 96              | 52       | 67      | 63      | 81              | 55       | 56      | 58    |

## CHAPTER IV

### SUMMARY AND CONCLUSIONS

#### Summary

The purpose of this study was to determine the effect on seventh grade pupils of a particular method of reteaching in two areas of arithmetic achievement: namely, concepts and problem solving.

The problem was subdivided (1) to determine, at three levels of ability, whether an experimental section using a systematic method of reteaching would show greater gains in arithmetic achievement in the area of concepts and problem solving than a control section not using the method, and (2) to compare the achievement of the experimental and the control sections in those areas of arithmetic concepts involving whole numbers, fractions, and decimals.

Achievement in Arithmetic Concepts. It was found on the basis of this study that for Group A-1, the group which was compared for achievement in arithmetic concepts, that the experimental section showed a gain when compared with the control section. The  $t$  ratio for the difference

of mean gain was .06 which is not statistically significant at the 5 per cent level.

The test on arithmetic concepts showed that the upper level of the experimental section of Group A-1 made an average gain of 11.7 months compared with 8.1 months' gain for the control section. The t ratio for the difference of mean gain was 1.33 which is not significant. The middle level of the experimental section showed an average gain of 6.3 months compared with 8.7 months' gain for the control section. The t ratio for the difference of mean was a negative 1.02 which was not significant. The lower level of the experimental section showed an average gain of 8.8 months compared with 6.2 months' gain for the control section. The t ratio for the difference of mean gain was 1.04 which was not significant.

Achievement in Arithmetic Problem Solving. It was found on the basis of this study that for Group A-2, the group which was compared for achievement on arithmetic problem solving, the experimental section showed a gain when compared with the control section. The t ratio for the difference of mean gain was .25 which is not statistically significant at the 5 per cent level.

The test in arithmetic problem solving showed that

the upper level of the experimental section of Group A-2 made an average gain of 8.6 months compared with 5.3 months' gain for the control section. The t ratio for the difference of mean gain was .94 which is not significant. The middle level of the experimental section showed an average gain of 1.1 months compared with 3.1 months' gain for the control section. The t ratio was a negative .62 which is not significant. The lower level of the experimental section made the largest gain, an average of 12.7 months, compared with 3.5 months' gain for the control section. The t ratio for the difference of mean gain was 3.19 which is significant at the 5 per cent level and at the 2 per cent level.

#### Achievement in Three Areas of Arithmetic Concepts.

It was found on the basis of this study that the experimental plan used with the experimental group was not superior in teaching those skills involving whole numbers, fractions, and decimals on the test for arithmetic concepts. The upper level of the experimental group showed some gain in the area of fractions but the t ratio of 1.125 was not significant. The lower level of the experimental group showed some gain in the area of decimals, but no t ratio was found for this or for any other section of the test involving skills.

### Conclusions

The following conclusions seem justified on the basis of the data gathered during the study: the mean gain of the upper and lower levels of the experimental section of both Group A-1 and Group A-2 was greater than for the control section. The mean gain of the middle level of the experimental section of both Group A-1 and Group A-2 was slightly lower than the gain of the control section. The mean of the lower level of the experimental section of Group A-2 differed significantly at the 2 per cent level from the mean of the control section. The achievement of the experimental section of Group A-1, in the area of arithmetic concepts involving whole numbers, fractions and decimals, did not differ significantly from the achievement of the control section at any of the three levels of ability.

The experimental plan of reteaching was more effective with the upper and lower levels of a group than with the middle level of a group. The plan was particularly effective with the lower level of experimental section compared on problem solving.

### Suggestions for Further Study

The following is a list of suggestions for further

related study:

1. A study using the experimental plan of reteaching with a larger population.
2. A study using this plan adapted to the needs of an above average group of pupils.
3. A study using this plan modified to meet the needs of a group of low ability pupils.
4. A study using the plan of reteaching, concentrating on a single topic over a short period of time (two to four weeks).
5. A comparison of this method of reteaching with other methods of reteaching.
6. A study to determine why the method was ineffective with students of the middle level of ability.
7. A similar study using a test instrument designed especially for the experiment.
8. A study involving other methods of reteaching using the same amount of class time.

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**APPENDIX**

## SAMPLES OF MATERIALS USED

Symbols

1. Numerals of the decimal system 1, 2, 3, 4, 5, 6, 7, 8, 9, 0.
2. Sign for addition: plus sign, "+".
3. Sign for subtraction: minus sign, "-".
4. Signs for multiplication:
  - a. the times sign "x" as  $4 \times 2$ .
  - b. the raised dot "." as  $4 \cdot 2$ .
  - c. the parentheses "( )" as  $(9)(2)$ .
5. Signs of division:
  - a. the division sign "÷" as  $4 \div 2$
  - b. the " ) " as  $2 \overline{)4}$
  - c. the bar "-" as  $\frac{4}{2}$ .
6. The sign of equality "=" as  $\frac{2}{5} = \frac{3}{15}$ .
7. The sign of inequality " $\neq$ " as  $4 \neq \frac{5}{3}$ .
8. The exponent  $a^b = a \ a \ a \ \dots \ a$  where b is the  
number number of factors.
9. The decimal point ".".

Sample of Problems Involving Whole Numbers

$7-2+3=$

$6+3-2=$

$6-4-2=$

$5+3 \times 4=$

$12-5 \times 2=$

$4+6-7=$

$9-3 \times 3=$

$9-4+5=$

$8-5+2=$

$7+2 \times 6=$

$25-3 \times 6=$

$10+5 \times 2=$

$8+3 \times 4=$

$8+2 \times 4=$

$10-8+2=$

$(2)^2+1=$

$4^2-1=$

$2(3)^2=$

$3^2+2^2+1^2=$

$3(3-2)=$

$2 \times 3(3+2-1)=$

$18-8+4=$

$8+6 \times 3=$

$14-10+2=$

$7+9+2=$

$16+2+4-5=$

$5 \times 3-4=$

$18-6(6-3)=$

$5(8-4)=$

$7(5+7-8)=$

$4 \times 3^2-10=$

$10 \times (20+4)-5^2=$

$(2+8 \times 6)(2+6)=$

$4(2+3)+35+5=$

$4 \times 4-4+2=$

$5^2+25=$

$(4+15)(2+5)=$

$(2 \times 3-4)^2=$

$2 \times 2^2+3 \times 5^2-4^2=$

$3(5)(2)^2-20+4=$

$4^2-2 \times 8+6^2+12=$

$(3^2+18+3)+6=$

$2(7-2)-3^2+3(1+5)=$

$2(6)^2(8)-15=$

$(8+20+5)^2=$

$6(2 \times 3+4)(10)(0)=$

$2[3 \times 4+15+3]-2.7+0.9=$

Sample of Problems Involving Fractions and Whole Numbers

$$(1 - \frac{1}{2}) + (8 - 7) =$$

$$4 + (\frac{1}{4} + \frac{1}{21} + \frac{1}{4}) =$$

$$(\frac{1}{3} + \frac{2}{3})(\frac{4}{3} - \frac{1}{3}) =$$

$$(\frac{1}{4} + \frac{1}{4}) + (\frac{3}{4} - \frac{1}{4}) =$$

$$(\frac{1}{2} - \frac{1}{4})(16 \times \frac{1}{4}) =$$

$$(\frac{1}{4} \times \frac{8}{11}) + (\frac{3}{4} + \frac{3}{4}) =$$

$$\frac{7}{8} \times \frac{8}{9} \times \frac{9}{10} + \frac{3}{10} =$$

$$\frac{4}{5} = \frac{1}{5} + \frac{2}{5} = \frac{1}{5} =$$

$$\frac{1}{2} \times \frac{6}{27} \times \frac{3}{17} + \frac{10}{34} =$$

$$(\frac{4}{5} \times \frac{5}{6} \times \frac{6}{7} \times \frac{7}{8}) + \frac{1}{2} =$$

$$(\frac{2}{3} + \frac{3}{2} \times \frac{2}{3}) + 4 =$$

$$(\frac{2}{3} \times \frac{3}{4} - \frac{1}{4})(\frac{4}{5}) =$$

$$(\frac{1}{4} \times \frac{4}{6} + \frac{2}{5} \times \frac{5}{6}) - \frac{1}{2} =$$

$$(21 \times \frac{1}{3}) + 7 =$$

$$(\frac{1}{4} \times 36) + 3 =$$

$$(\frac{4}{5} + \frac{1}{5}) + (5 - 2) =$$

$$(\frac{2}{3} - \frac{1}{3} + \frac{1}{3}) + (4 \times \frac{1}{2}) =$$

$$\frac{21 \times 3 \frac{1}{7}}{11 \times 2} =$$

$$\frac{18 \times 2 \frac{1}{4}}{7 - 5} =$$

$$\frac{2 \frac{1}{2} \times \frac{2}{5}}{5 \frac{1}{3} \times \frac{3}{4}} =$$

$$\frac{\frac{1}{64} \times \frac{3}{10} + \frac{1}{8}}{5} =$$

$$\frac{\frac{1}{2} \times 1 \frac{1}{3}}{\frac{3}{8} \times 2 \frac{2}{9}} =$$

$$\frac{10}{\frac{7}{12} \times \frac{41}{45}} =$$

$$\frac{\frac{3}{55} \times \frac{1}{22}}{30 + 6} =$$

$$\frac{\frac{3}{4} + 6}{\frac{5}{8} + 2} =$$

$$\frac{(\frac{3}{4} \times \frac{4}{5} \times \frac{5}{6} \times \frac{2}{3}) + \frac{1}{3}}{3 - \frac{1}{2}} =$$

Sample of Problems Involving Numbers in Decimal Form

$(1 \rightarrow 5) + (1 \rightarrow 5) =$

$(100 \times .032) - 3.2 =$

$320 + (100 \times 3.2) =$

$(10 \times 64) - 640 =$

$(64 + 10) - 6.4 =$

$(6.4 + 10) + (320 + 100) =$

$(3.2 + 100) + (6.4 \times 10) =$

$(.1 + .001) + .101 =$

$(1.1 - .1) \times 11 =$

$(.1 \times .3) + .04 =$

$(.75 + .25) + (.75 - .25) =$

$(1 - .25) + (.5 - .25) =$

$(.1 \times 1) + (0.0 \times 1) =$

$(10 \times .001) - .01 + 4 =$

$(.7 + .3) + (.07 + .03) =$

$(.5 + .50) - (.25 + .5) =$

$(1.11 - .01) + (10 + 1) =$

$(.2 \times .2) + (.2 \times .02) =$

$(.02) (.02) - (.02 \times .02) =$

$\frac{.1 \times .1}{10} =$

$\frac{.2 + .2}{100} =$

$\frac{10 + 10}{.1 + .2} =$

$\frac{.25 + .75 - .25}{.50 + .25} =$

$\frac{.125 \times 100}{.25 - .125} =$

$\frac{.375 + .125}{5 + 10} =$

$\frac{.333^1 + .663^2}{.625 - .125} =$

$\frac{.003 + .03 + .3}{.333 - .033} =$

$\frac{.111 - .011 + 1}{10 + 10} =$



## Word Problems

Mr. Hart drove 82 miles in  $2\frac{1}{2}$  hours. Find the average rate of speed in miles per hour.

Mr. Smith traveled 490 miles on 40 gallons of gasoline. How many miles did he average for one gallon?

At an average of 275 miles per hour, how far can an airplane travel in 8 hours?

A certain jet plane travels 11.6 miles a minute. How many miles per hour is this?

An airplane flew a distance of 8193 miles in 30 hours. Find the average rate of speed to the nearest tenth of a mile.

Mr. Jones bought 10.3 gallons of gas at 31.9¢ a gallon. What was the cost?

Find the average of these three numbers to the nearest tenth of a foot: 2.8 feet, 3.5 feet, 2.5 feet.

The bus line charges \$.0185 for each mile. What will it cost me to ride on the bus for a trip of 100 miles?

There were 165 persons at the school carnival. The total amount of money received was \$247.50. On the average what did each person spend?

A farmer sold a steer that weighed 1000 lbs. for \$222.50. How much did he receive per pound? (Do not round answer).

The 4-H Club has 60 members. They represent 20% of the entire school enrollment. How many students are there in the school?

In a school of 150 pupils all but 4% went on a picnic. How many went? How many did not go?

The Wilsons allow 33% of their monthly salary of \$400.00 for food. How much do they spend for food?

In a certain science class there are 39 boys and 11 girls. What per cent of the class are boys and what per cent are girls?

Ann answered correctly all 76 questions on a test and was marked 100%. What per cent should be marked on a paper that had 67 correct answers? (Round to the nearest whole per cent).

Last year 1485 people lived in my town. This year there are 1782 people. Find the per cent of increase.

Last year John earned \$480.00. This year he earned only \$408.00. Find the per cent of decrease in his earnings.

Last season our baseball team won 9 games. This was 60% of all games played. How many games did we play?

The total cost to a shopkeeper of a certain chair which he sells is 80% of its selling price. If the chair cost him \$48.00, at what price does he sell it?