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Date June 29, 1972

THE EFFECTS OF PRACTICE AND USAGE ON BASIC ARITHMETIC SKILLS

by

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TABLE OF CONTENTS

	Page
LIST OF TABLES	vi
ABSTRACT	vii
Chapter	
1. INTRODUCTION	1
Statement of the Problem	1
Purpose of the Study	2
General Questions to be Answered	3
General Procedures	3
Limitations	5
Definition of Terms	6
Summary	7
2. REVIEW OF THE LITERATURE	8
Introduction	8
Ideas and Thoughts on Practice and Usage	8
Studies Done on the Effects of Practice and Usage	11
Summary	15
3. PROCEDURES	17
Introduction	17
Subjects of the Study	17
Experimental Treatment	18
Methods of Collecting Data	19

Chapter Page

Methods of Organizing Data 20

Statistical Hypotheses 21

Analysis of Data 21

Summary of the Procedures. 22

4. ANALYSIS OF DATA 24

Summary. 27

5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS. 28

Summary. 28

Conclusions. 28

Recommendations. 29

APPENDICES. 30

A. Diagnostic Test on Fundamentals 31

B. Instructional Worksheets Keyed to Diagnostic Test 33

C. Experimental Worksheets 37

LITERATURE CITED. 44

LIST OF TABLES

Table | Page

1. Raw Score Data Compiled from the Study. 25
2. Mean Differences of Subgroups 27

ABSTRACT

The purpose of this study was twofold: (1) to develop a program for improving and maintaining arithmetic skills, and (2) to develop a method of testing that program to determine if it had any effect upon those exposed to it. The first half of this twofold purpose was carried out by developing a series of worksheets which covered the basic areas of arithmetic computation. These worksheets were designed so as to require a minimal amount of time to complete. The purpose of the worksheets was to give continued exposure to the basic arithmetic skills without spending a great deal of time.

The second half of the purpose of this study was to create an experimental situation which would determine the effect the worksheets had on the subjects' ability to perform basic arithmetic skills. This was done by using three first year algebra classes as the subjects of the study. One class was designated the experimental group and the other two the control group. After a week of instruction in basic arithmetic skills was given to both groups, the experimental group then received twenty-four experimental worksheets over an eight week period. At the conclusion of the eighth week, both the control group and experimental group were tested.

The data collected was then compared on the basis of matched-pair samples. The comparison was carried out by means of a 't' test analysis at the α=.05 level of confidence in order to determine if there was any significant difference between the control and experimental groups at the conclusion of the experiment. It was found that a significant difference did occur in favor of the experimental group. Therefore, the conclusion drawn was that practice and usage, as applied in this study, did indeed have a positive effect in improving and maintaining arithmetic skills.

Chapter 1

INTRODUCTION

Today's world seems to be one filled with all kinds of modern conveniences that make life more pleasant for the average man. One of the more popular of these conveniences is the small calculator which carries out the basic operations of arithmetic with great speed and accuracy. To operate such a calculator requires only that the operator know when to add, subtract, multiply, or divide, and not necessarily how to perform these operations. However, it seems logical to think, at least in the near future, that most people will still find the need to possess a working knowledge of the arithmetic skills, if only to balance their checkbook. The question that seems to arise from this last statement is do today's mathematics' programs provide for the development of mathematical concepts around which most "Modern Math" programs seem to be centered.

Statement of the Problem

As a mathematics teacher, one of the most common complaints this researcher hears from fellow educators and others is that students today seem to be weak in the area of arithmetic skills. Of course, blame in many cases is placed on the failure of the "Modern Math" program to develop fundamental skills of arithmetic computation. However, it is the feeling of this researcher that such blame is misplaced. The

problem lies not so much in the developmental process but rather in the lack of most programs to provide for practice and usage of the skills once they have been developed. Therefore, the problem this study addressed itself to was to determine the effect practice and usage had on the maintenance and improvement of basic arithmetic skills in a first year algebra class.

Purpose of the Study

During the past few years, this researcher has been looking for a program which would help develop and maintain the arithmetic skills of students. While some programs were found, most required more class time than this researcher felt could be justified. With this in mind, a twofold problem was set forth which became the purpose of this study. The first was to develop a program for the purpose of developing and maintaining arithmetic skills that was so simple that very little class time or student study time would be sacrificed. This was accomplished by developing a set of worksheets which gave continued exposure to the four fundamental operations of addition, subtraction, multiplication, and division of whole numbers, mixed numbers, fractions, and decimal fractions. Also included were problems dealing with per cent. Each worksheet was designed to cover a certain area of these skills and at the same time not to require more than three or four minutes time for the average student.

The second part of the purpose of this study was to develop a method of testing the new program to see if the worksheets did create any significant difference in the students' fundamental arithmetic skills. This was done by creating a control group which was not given the worksheets and an experimental group which was given the worksheets. Then, by using the numerical aptitude scores of the Differential Aptitude Test, matched pairs were created so that upon completion of the experiment the researcher could administer a standardized test and compare the results using the theoretical model of the distribution of 't' to determine if any significant difference between the experimental and the control group was present.

General Questions to be Answered

At the conclusion of this study, it was hoped that the results would answer two basic questions: (1) Did the worksheets designed by this researcher bring about any significant improvement in the experimental group as opposed to the control group?, and (2) If any significant change was noted, did it appear throughout the experimental group or did the change manifest itself within some subgroup of the experimental group?

General Procedures

This nine week study focused around three first year algebra classes which were assigned to this researcher at Lincoln Junior High

School in Billings, Montana. At the outset of the study, one of the three classes was selected to serve as the experimental group, while the other two classes combined served as the control group.

The first week of the study served as an instructional period. During this week, the students were given a diagnostic test (see Appendix A, page 31) which was designed to help them determine their weaknesses in performing the basic fundamental operations of addition, subtraction, multiplication, and division as they are carried out with whole numbers, mixed numbers, fractions, and decimal fractions, as well as some problems involving per cent. Using the results of this test, students were then able to obtain instructional worksheets (see Appendix B, page 33) which corresponded to those problems which they missed on the test. Following this, this researcher spent ten or fifteen minutes during each of the next four class periods giving instructions in each of the skill areas. The remainder of the period was reserved for the student to complete his instructional worksheets, check his own work, and get individual help if he felt he needed it.

At the conclusion of the first week of the study, no further instruction was initiated by this researcher, except as it arose in the regular subject matter in a first year algebra class. However, all student initiated questions were answered upon request. During the next eight weeks of the study, the experimental group began receiving the experimental worksheets (see Appendix C, page 37) on Monday, Wednesday,

and Friday. Monday's worksheet was due on Wednesday, Wednesday's was due on Friday, and Friday's was due the following Monday. Each weeks' worksheets were designed to cover all the areas of concern to this study. On Monday, Wednesday, and Friday, the first few seconds of the period were taken to read the answers to the worksheet due that day; then they were collected. No class time was used at this time to answer questions. However, following the daily lesson if some time remained in the class period, questions would be answered individually while the remainder of the class worked on their algebra assignment.

Upon completion of the eight week period and twenty-four worksheets, both the experimental group and the control group were given the Survey of Mathematics Achievement Test, and the results were recorded. The results of the experimental group were then compared to the control group on the basis of matched pairs and the use of a 't' test to determine whether there was any significant difference at the $\alpha = .05$ level. The matched pairs were formed by matching each member of the experimental group with a member of the control group based on the numerical aptitude score of the Differential Aptitude Test.

Limitations

This experimental situation was limited to three first year algebra classes at Lincoln Junior High School in Billings, Montana. Since this study was based around matched pairs which were determined by the numerical aptitude score of the Differential Aptitude Test, the

results of this study were subject to the reliability and validity of the D.T.A. In addition, the results of this study were also limited to the reliability and validity of the Survey of Mathematical Achievement Test, which was used to measure the difference between the control and experimental groups.

Definition of Terms

The language of this study is composed of terms commonly used in education. The following terms are listed so that the reader will be able to interpret them in the same manner as the researcher.

Arithmetic skills. Those tools which are needed to perform the operations of addition, subtraction, multiplication, division, and work with percentages.

Computational ability. One's ability to perform arithmetic skills.

Control group. The one of two or more groups that is not subjected to the experimental factor introduced into the treatment of the experimental group (Good, 1:191).

D.A.T. The abbreviation for Differential Aptitude Test.

Experimental group. The one of two groups that is subjected to the experimental factor; the effect of which it is the purpose of the

experiment to discover (Good, 1:191).

Numerical aptitude. The numerical aptitude score of the D.A.T.

S.M.A. The abbreviation of the Survey of Mathematical Achievement Test.

Summary

The purpose of this study was to see whether the method developed by the researcher had any effect on the ability of his students to perform arithmetic skills.

This study was conducted at Lincoln Junior High School in Billings, Montana, and involved three first year algebra classes. One of the classes was designated as the experimental group and was subjected to the experimental factor. The other two were designated the control group and were not subjected to the experimental factor. The experiment covered a nine week period, and at the conclusion of that period both experimental and control groups were tested. Using these test results, the groups were compared on the basis of matched pairs. A 't' test was used to determine if there was any significant difference.

Chapter 2

REVIEW OF THE LITERATURE

Introduction

The scope of this professional study was twofold: (1) the development of a program which provided for practice and usage of basic arithmetic skills in a first year algebra class, and (2) the organization of an experimental situation which was used to evaluate the said program. The following review of available literature served as a guide to that end and was organized in two parts. The first part of the review deals with past and present ideas and thoughts of educators on practice and usage as a method of developing and maintaining basic skills. The second portion of this review examines other studies done on the subject of practice and usage as a method of improving skills.

Ideas and Thoughts on Practice and Usage

At the outset of this section of the review of literature, this researcher would like to point out to the reader that many authors use the term "drill" when referring to what this researcher calls practice or usage. It is the intent of this study to use the terms interchangeably.

In the past seventy years, the concept of practice or drill has undergone some significant changes in the minds of educators. Ben A. Sueltz (7:192) points out in an article written in 1953 that twenty-five

years ago drill was a very common method of learning. However, during the ten-year period from 1935 to 1945, drill had been carried to such extremes that it became frowned upon by educators as a method of learning. More recently, drill has again become part of the learning process but in a new light; not drill for the sake of drill, but rather as a complement to the learning process so that what is learned can become functional for the individual.

In the process of reviewing the literature, this researcher has found that most educators writing on the subject of practice or drill today generally tend to agree that it is an acceptable method of achieving some of the objectives of a mathematics program. The authors of the text, The Teaching of Secondary Mathematics, state the general feeling in this statement:

> Drill must be recognized as an essential means of attaining some of the desired controls, just as a strong emphasis on concepts and meanings and patterns and relationships must be recognized as being essential for understanding. Both are necessary; neither alone is sufficient. Many of the operations of mathematics need to be performed not only correctly, but with considerable facility and speed, if they are to be most useful. Some of them need to be actually automatized. Facility in such operations can be attained only through systematic and repeated practice in using them; i.e., through drill (Banks, 1:130).

The question that arises now is when does a teacher employ practice or drill in the development of a specific skill? Max A. Sobel (8:292-95) in an article entitled "Skills" offers some specific suggestions for skill development. The most timely of these suggestions is that before development of the skill must come the understanding of the

skill. For example, in teaching addition of fractions, the teacher must first instill in the learner the need for a common denominator. Next, the teacher must show the student a procedure for finding a common denominator and why that procedure works. W. G. Quast (6:628), a professor at Slippery Rock Bible College whose major responsibility is teaching content and method courses in elementary school mathematics, re-emphasizes this in his article, "On Computation and Drill". Mr. Quast points out that drill, in itself, is not a good learning device. He says to tell Johnny to do thirty addition problems because he is having trouble in addition is ridiculous. All this does is reinforce in Johnny's mind his lack of ability to perform the operations of addition. The answer then to the question of when should a teacher employ practice and drill in skill development seems to be only after understanding.

Another area to which practice or usage would seem to have a direct effect would be in the maintenance of some skill. Surely a track coach would not expect his pole vaulter to maintain or improve his jumping height without practice. Does it seem logical then for a mathematics teacher to expect his students to maintain their basic skills without practice? The authors of The Teaching of Secondary Mathematics point out that if a skill is not used it soon becomes vague and fuzzy, and the procedures can become uncertain. Here it would seem that carefully planned, cumulative drill could play a significant part in the maintenance

of a skill (Banks, 1:132).

Before leaving this section of the review of literature, it would be worthwhile to look at one more of Max A. Sobel's (8:295) suggestions for the development of skills. Mr. Sobel warns that routine drill that tends to be mechanical must be avoided. He states, "To be effective, drill must be varied. The structure of the drill situation should force the student to think about each problem."

Studies Done on the Effects of Practice and Usage

This review of literature now turns its attention to three studies, all of which have been done in the last ten years. All three of these studies deal with some aspect of the effect practice and usage have on a student's ability to perform basic arithmetic operations.

In 1963, G. H. Miller (5:117), a professor of mathematics at Edinberg State College in Pennsylvania, carried out a study which he entitled "Theory or Practice in Arithmetic--Which Shall it Be?". The hypothesis of the study was whether or not theory in mathematics eliminates the need for a great amount of computational drill? He drew his sample from 137 students in the class of entering college freshmen who did not meet the criterion of the fiftieth percentile of the ninth grade norms on the Madden-Peak Arithmetic Test. The 137 students were then divided into two groups. One of these was called the modified traditional group and the other the modern group. The modified traditional

group was subjected to lecture class five days a week followed by a workshop three days a week. The textbook used by this group contained most of the modern concepts, but Mr. Miller purposely omitted the major topics of set theory and logic to allow more time for practice and drill.

The second group of students, the modern group, were lectured to five days a week and were provided with workshops for extra help. Unlike the traditional group, the modern group covered all the material in the text and was not provided with the extra practice and drill time (Miller, 5:117).

At the completion of seven weeks, the modern group and the modified traditional group were compared, and Mr. Miller found a most significant difference in favor of the modified traditional group; and, therefore, concluded that arithmetic skills are greatly improved by practice (Miller, 5:119).

In 1965, another study was carried out which was similar to G. H. Miller's, but it was done in a much different setting. This study was done by Elmer A. Koch Jr. (4:9), who is a fifth grade teacher in Calhoun Elementary School in Minneapolis. His study was entitled "Homework in Arithmetic", and it was built around the question, does homework increase arithmetic achievement. The study was done with three sixth grade classes in one school. These three classes were divided into three groups: (1) full group--which received long daily

homework assignments, (2) half group--which received a relatively short daily homework assignment, and (3) control group--which received no daily homework assignments.

All three of these groups were taught the regular arithmetic curriculum by the regular classroom teachers. All of the groups used the same textbooks and covered the same material. Weekly conferences with the classroom teachers were held to determine the content of the homework assignments. Mr. Koch then produced and corrected the assignments himself (Koch, 4:10).

While the data obtained from this experiment was not sufficient to make the claim that homework will increase achievement in arithmetic, some of the data did lean in this direction. Based upon the results of the full group, it did appear that daily homework assignments are a significant factor in raising the achievement level of learning in the area of arithmetic computation. The results of the half group were not significant in the area of computation, which the author points out might indicate that longer homework assignments are in order (Koch, 4:12).

In the area of problem solving, neither the full group nor the half group showed a significant improvement. The author offers as an explanation the fact that problem solving involves the complex skill of reasoning, and this is something that cannot be developed by the practice-type assignment (Koch, 4:12).

As a result of his study, Mr. Koch (4:13) draws a conclusion which seems to support what this review of literature earlier found to be the opinion of many educators. Koch concludes that the question is not "'What good is homework in arithmetic?' Rather, the question becomes, 'What is homework in arithmetic good for?'" In other words, not drill for the sake of drill, but meaningful drill which will help in the development of a skill.

Roland F. Gray, a professor of education at the University of British Columbia (3:199), published a study entitled "An Experiment in Teaching of Introductory Multiplication", in the March, 1965, issue of the Arithmetic Teacher. The hypothesis of his study was that introductory multiplication could be learned equally well, if not better, by understanding of the distributive property, as opposed to practice.

Mr. Gray (3:199-200) performed his study with 480 third grade students. All the students received the same basic introduction to multiplication. That introduction was the method of repeated additions. Following this uniform introduction, the students were divided into two groups. In the first group, a great deal of time was allowed for practice and memorization of the multiplication combinations, but no mention of the distributive property was made. In the second group, all of multiplication was explained in terms of the distributive property. As a result of this, the second group had less time for drill. Also, no attempt was made for the second group to memorize the multiplication

combinations.

At the conclusion of his study, Mr. Gray (3:201-202) measured his results three ways. First, he used a paper and pencil test which was devised to determine the students' actual ability to perform the operation immediately following the experiment. This test revealed no significant difference between the two groups. At a later date, he employed a similar test to determine retention of the skill and found a significant difference which favored the second group. Finally, as a third method of measuring his results, Mr. Gray used the personal interview to determine if: (1) the subject could give a rational explanation of the multiplication procedure or whether he gave a rote answer, and (2) to see if there was any evidence of the ability to apply the distributive property. On both counts, Mr. Gray found that the second group performed at a higher level.

Summary

This review of literature was organized in a way which would supply this researcher and the reader some knowledge of the effects of practice and usage on the development of a skill. In order to do this, the review was divided into two parts. The first part dealt with past and present ideas and thoughts of educators on the subject and the second part with the results of some studies done on the subject.

In review of the history of practice or drill, it seems that about the turn of the century this was a very acceptable method of

teaching and was used extensively. However, during the ten year period from 1935 to 1945, practice and drill had been carried to such extremes that they lost favor in the eyes of the educators. Following this period, drill once again was finding its way back into the educational process, but in a new light; not drill for the sake of drill, but only as a device to develop a skill so that skill could become functional. Today, there seems to be a general agreement that the use of drill should only follow understanding.

The studies which were included in this review of literature seem to coincide with the feelings of the educators. For example, R. F. Gray's study emphasized understanding, and the results revealed significant improvement in the areas of retention and understanding. This presents a strong case for the idea that understanding must precede practice. The studies done by Koch and Miller, on the other hand, showed that drill could be used effectively as a device for improving some skills.

Perhaps if the feelings of the educators and the results of the research were combined, the conclusion would be that practice or drill could be effective in developing skills, but that they should not be employed until understanding of the skill is present.

Chapter 3

PROCEDURES

Introduction

The purpose of this study was to determine the effects practice and usage had on the maintenance and improvement of basic arithmetic skills. It is the purpose of this chapter to explain the procedures followed in determining: (1) how those students involved in the study were chosen; (2) to explain the experimental variable to which the experimental group was exposed; (3) the devices and methods which were used in collecting data; (4) how the data was organized; (5) a statement of the statistical hypotheses; and (6) the procedures which were followed in analyzing the data.

Subjects of the Study

This study was focused around seventy-eight ninth grade algebra students who comprised three algebra classes assigned to this researcher at Lincoln Junior High School in Billings, Montana, during the 1971-1972 school year. One of these classes, which contained twenty-eight members, was selected to serve as the experimental group and was exposed to the experimental variable.

Since no attempt was made to select these students at random, some method had to be employed to equate the control and experimental groups at the outset of the study. Prior to the outset of the study, all ninth grade students at Lincoln had taken the Differential Aptitude

Test. The numerical aptitude scores of this test were used to form matched pairs by matching members of the experimental group with members of the control group whose numerical aptitude scores were the same on the D.A.T.

Experimental Treatment

During the first week of this nine-week study, both the experimental and the control groups were subjected to a review situation in the four basic skills of addition, subtraction, multiplication, and division, as they are carried out with whole numbers, mixed numerals, fractions, and decimal fractions. Also included in this was the area of percentage problems. This review was carried out by administering a diagnostic test (see Appendix A, page 31) on the first day of the study. This test was designed to help the students locate the areas in which they were weak. The students then obtained instructional worksheets (see Appendix B, page 33), which were coordinated with the area in which they needed work. During the last four days of the week, this researcher spent the first ten to fifteen minutes of each period going over the various areas for groups of students who were having trouble with a specific area. The remainder of each period was set aside for class work which gave students a chance for individual attention.

Upon completion of the first week, no further instruction was initiated by this researcher, except as it arose in a first year algebra class. However, all students' questions were answered upon their

request. At this point, the experimental group began receiving the experimental worksheets (see Appendix C, pages 37-43) on Monday, Wednesday, and Friday. Monday's worksheet was due on Wednesday, Wednesday's worksheet was due on Friday, and Friday's worksheet was due the following Monday. On Monday, Wednesday, and Friday, the first few seconds of each class were taken to correct the worksheets, thus enabling the students to see which problems they missed so that they could seek help on their own time. Each weeks' worksheets covered all the areas of concern to this study and were designed so as to require a minimal amount of time by the students. At the conclusion of the eight weeks, or twenty-four worksheets, by the experimental group, the S.M.A. test was administered to both the experimental and the control groups. These results were then compared on the basis of matched pairs, which had previously been determined, by the numerical aptitude score of the D.A.T. to determine if any significant difference was present.

Methods of Collecting Data

The first data collected for this study was the numerical aptitude scores of the Differential Aptitude Test. These scores were obtained from the guidance department at Lincoln Junior High School and were used in the initial phase of the study to establish equality between the control group and the experimental group on the basis of matched pairs. The other data used in this study was obtained from the scores of the Survey of Mathematics Achievement Test taken by both the

experimental and control groups upon completion of the experiment. The scoring of the Differential Aptitude Test was done by machine, while the scoring of the Survey of Mathematical Achievement Test was done by the researcher with the aid of an answer key supplied by the test manufacturer. The reliability and validity of the two tests are reported below.

Test	Reliability	Validity
D.A.T.	.90	.62
S.M.A.	.90	

Methods of Organizing Data

Once the researcher had received the numerical aptitude scores of the D.A.T. and the matched pairs had been established, a six column table was constructed. The first column identified the matched pair, and the second column the numerical aptitude score received by the pair. The third and fourth columns were reserved for the scores of the S.M.A. Test taken at the conclusion of the study. The fifth and sixth columns were used to report the difference in the scores of the S.M.A. which were received by the experimental and control member of each pair and the square of that difference. This last data was necessary for calculating the statistics of this study.

Statistical Hypotheses

Verbally, the null hypothesis of this study was: there was no difference in the achievement of the experimental group and the control group in performing basic arithmetic skills. The corresponding alternate hypothesis was: the achievement of the experimental group in performing basic arithmetic skills was greater than that of the control group.

Algebraically, the null hypothesis and the alternate hypothesis were:

$$H_0: \mu_E = \mu_C$$

$$H_1: \mu_E > \mu_C$$

where μ_E was the mean achievement of the experimental group and μ_C was the mean achievement of the control group.

Analysis of Data

The data which was obtained from the Survey of Mathematical Achievement Test administered at the conclusion of the study was analyzed to determine if any significant difference existed between the experimental group and the control group. The theoretical model that was used to determine this significance was the distribution of 't'.

The statistical analysis was based around the matched pairs of the experimental group and control group, as was determined by the numerical aptitude score of the D.A.T. It was assumed that this matching

equated the paired individuals in such a way that the difference between their abilities to perform basic arithmetic skills was zero.

Once the test scores of the Survey of Mathematical Achievement Test had been compiled at the completion of the study, the researcher calculated the difference between the scores made by the paired individuals. Following this, the mean of the distribution of differences was calculated along with the variance and standard deviation. The researcher then solved for the 't' statistic.

The level of significance for this study was the $\alpha = .05$. From the table of 't', the researcher was then able to determine whether to retain or reject the null hypothesis. The test was regarded to be a one-tailed test.

Summary of the Procedures

Three classes of students taking first year algebra at Lincoln Junior High School in Billings, Montana, were the subjects of an experimental study to determine the effects of practice and usage on basic arithmetic skills. In order to accomplish this, one class was considered the experimental group and the other two the control group. The experimental group was exposed to the experimental variable for a period of eight weeks. At the conclusion of this eight week period, a standardized test was administered to both the experimental and the control groups. With all other variables being held constant, the results of the test scores received by the experimental and the control groups were

compared. A 't' test was then used to determine if the null hypothesis was to be retained or rejected. The level of significance was $\alpha = .05$ for a one-tailed test.

Chapter 4

ANALYSIS OF DATA

The purpose of this study was to determine the effects that practice and usage have on the basic arithmetic skills. In order to accomplish this, an experimental situation was established which allowed the researcher to compare ninth grade algebra students who had been exposed to the variable factor of practice and usage of arithmetic skills over an eight week period to those students who had not been exposed to the variable factor. This comparison was done by carrying out a one-tailed 't' test at the $\alpha = .05$ level of significance on the data collected.

Table 1, page 25, shows the data which was compiled at the conclusion of the study.

Using the data reported in Table 1, the following statistics were computed: (1) the mean score of the experimental group on the S.M.A., symbolized $\overline{X}$; (2) the mean score of the control group on the S.M.A., symbolized $\overline{Y}$; (3) the mean of the distribution of differences of scores received by experimental group and the control group on the S.M.A., symbolized $\overline{D}$; (4) the variance of the distribution of differences, symbolized S_D^2; and (5) the standard deviation of the distribution of difference, symbolized S_D. The results were as follows:

$\overline{X} = 48.0$ $\qquad$ $S_D^2 = 27.01$

$\overline{Y} = 44.4$ $\qquad$ $S_D = 5.20$

$\overline{D} = 3.68$

Table 1

Raw Score Data Compiled from the Study

Matched Pair	Numerical Aptitude	X	Y	D	D^2
1	30	51	41	10	100
2	29	53	48	5	25
3	28	58	58	0	0
4	28	54	53	1	1
5	27	55	53	2	4
6	27	45	42	3	9
7	25	48	45	3	9
8	25	59	43	16	256
9	24	54	48	6	36
10	24	48	42	6	36
11	24	49	48	1	1
12	24	49	43	6	36
13	24	44	35	9	81
14	23	50	40	10	100
15	22	48	47	1	1
16	22	46	48	-2	4
17	21	48	39	9	81
18	20	37	43	-6	36
19	19	41	39	2	4
20	19	38	42	-4	16
21	17	38	40	-2	4
22	16	44	39	5	25
		$\Sigma X=1057$	$\Sigma Y=976$	$\Sigma D=81$	$\Sigma D^2=865$

X = score on S.M.A. by experimental group
Y = score on S.M.A. by control group
D = (X - Y)

Using the formula $t = \frac{\Sigma D}{\sqrt{\frac{N \Sigma b^2 - (\Sigma D)^2}{N - 1}}}$ the researcher solved for the 't' statistics and found it to be 3.32. Upon examining the table of 't' at the $\alpha = .05$ level with 21 degrees of freedom, it was found that in order for the experimental factor to have had a significant effect a 't' score greater than 1.721 would have to occur. Based on the fact that the 't' score determined by the data of this study exceeded 1.721, this researcher made the decision to reject the null hypothesis of this study in favor of the alternate hypothesis which stated, "The achievement of the experimental group in performing basic arithmetic skills was greater than that of the control group." This result gave an affirmative answer to the first general question to be answered by this study, namely, "Did the worksheets designed by the researcher bring about any significant improvement in the experimental group as opposed to the control group?"

The second question to be answered by this study was, "If any significant difference was noted, did it appear throughout the experimental group or did the change manifest itself within some subgroup of the experimental group?" Upon finding a significant difference, the researcher prepared Table 2, page 27, which subdivides the matched pairs into five subgroups based on their D.A.T. numerical aptitude score.

As can be seen in Table 2, the mean difference of each subgroup

Table 2

Mean Difference of Subgroups

Numerical Aptitude	N	ΣD	$\Sigma D/N$
28 - 30	4	16	4
25 - 27	4	24	6
22 - 24	8	31	3.9
19 - 21	4	1	.25
16 - 18	2	3	1.5

was calculated. While all the differences were of a positive nature, the data in this table does point out that the greatest improvement occurred in the top three groups which included approximately 72 per cent of those involved in the study.

Summary

In summary, the analysis of data shows that the experimental variable did indeed cause a significant improvement in the experimental group over the control group. The data also gave evidence that the improvement was greater in the top 72 per cent of the experimental group.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was twofold: (1) to develop a simple program for maintaining or improving basic arithmetic skills which would demand very little class time or student study time, and (2) to develop a method for testing that program. The first of these purposes was accomplished by developing a set of worksheets which covered the basic areas of arithmetic skills. The second purpose was accomplished by giving these worksheets to one of three first year algebra classes over a period of eight weeks. At the conclusion of these eight weeks, all three classes were tested and the results were compared on the basis of matched pairs. A 't' test analysis at the $\alpha = .05$ level of confidence was used to see if there was any significant difference between the group receiving the worksheets and those not receiving the worksheets. The results of the 't' test showed that the worksheets had created a significant difference in the students' ability to perform basic arithmetic skills.

Conclusions

The results of this study lead this researcher to the conclusion that practice and usage can have a positive effect on students' ability to perform basic arithmetic skills. Results also lead to the conclusion that the greater improvement will occur in higher ability groups,

although some improvement was noted throughout the entire group.

Recommendations

Upon completion of this study, many questions arose in the mind of this researcher about what effect changing some of the variable factors or even the group studied would have upon the results of this experiment. It was these questions that lead this researcher to make the following recommendations for further study in this area. It is recommended that:

1. A study be carried out using the same number of worksheets extended over longer periods of time.

2. A similar study be carried out with a larger group of students.

3. Similar studies be carried out using other groups of students, such as general mathematics rather than ninth grade algebra students.

APPENDICES

APPENDIX A

DIAGNOSTIC TEST ON FUNDAMENTALS

Use the symbols =, $>$, or $<$ to compare the numbers:

1.(a) $15 - 8 ____ 12 - 5$

1.(b) $6 + 9 ____ 8 + 8$

1.(c) $42 \div 7 ____ 54 \div 9$

1.(d) $8 \times 7 ____ 9 \times 6$

2.(a) $2/3 ____ 3/4$

2.(b) $1.5 ____ 2$

2.(c) $10^2 ____ 100$

2.(d) $.4 ____ .04$

Find the value of "n":

3.(a) $54 \div 6 = n$
$n = ____$

3.(b) $17 - n = 8$
$n = ____$

3.(c) $n + 7 = 15$
$n = ____$

3.(d) $8n = 56$
$n = ____$

Write the answers:

4.(a) $.9 - .3 = ____$

4.(b) $.9 \div .3 = ____$

4.(c) $.9 \times .3 = ____$

4.(d) $.9 + .3 = ____$

Find the sums:

5.(a)
$14.50
18.40
76.50
23.60

5.(b)
324,052
459,237
683,481
275,960

5.(c)
3 5/12
6 2/3
4 1/4

5.(d)
4 1/6
8 2/3
10 4/5

5.(e)
3hr 30min 20sec
4hr 45min 35sec
6hr 10min 8sec

Appendix A (continued)

Find the difference:

6.(a) $70.00 − 9.35

6.(b) 568,400 − 374,254

6.(c) 6 5/8 − 3 3/4

6.(d) 82 1/3 − 35 1/2

6.(e) 4yd 2ft 5in − 1yd 2ft 6in

Find the products:

7.(a) 5 1/3 X 2 1/4

7.(b) 951 × 906

7.(c) 56 X 7 5/8

7.(d) $57.90 × .68

7.(e) 3hr 30min × 3

Find the quotients:

8.(a) 3 3/4 ÷ 2 1/2

8.(b) $743 \overline{)673{,}158}$

8.(c) $100 \overline{)\$60}$

8.(d) $1.78 \overline{)818.8}$

Find the missing numbers:

9.(a) 8% of 150 = ____

9.(b) 16 is ____ % of 40

9.(c) 12% of ____ is 48

9.(d) 24 is ____ % of 500

APPENDIX B

INSTRUCTIONAL WORKSHEETS KEYED TO DIAGNOSTIC TEST

Questions 1 to 4

Use the symbol =, $>$ or $<$ to compare the numbers:

17 - 8 ____ 14 - 6 3 + 9 ____ 5 + 8 54 − 6 ____ 6 − 7 4 X 9 ____ 6 X 6

7/8 ____ 5/6 2.5 ____ 1.5 10^4 ____ 10,000 .02 ____ .025

Find the value of "n":

72 − 8 = n
n = _____

14 - n = 8
n = _____

n + 6 = 14
n = _____

9 X n = 81
n = _____

Write the answers:

.4 - .2 = ____ .4 − .2 = ____ .4 X .2 = _____ .4 + .2 = ____

5.(a) Add

1.2	.048	70.3	7.87	6.0008
6.4	.275	49.6	.03	3.0124
8.3	.538	32.4	1.08	.6819
7.2	.005	73.9	5.42	6.4508

5.(b) Add

43,270	62,501	49,687	42,345
84,921	52,633	45,684	66,300
90,638	16,395	36,970	43,476
36,495	44,707	89,705	76,634
			42,180

5.(c) Add

2/5	3 3/8	4 1/6	5 1/2	4 1/3
9/10	2 1/4	3 1/2	3 2/5	2 1/6
1/2	4 1/2	2 2/3	4 9/10	1 5/12

Appendix B (continued)

5.(d) Add

1/4	4 1/6	2 3/4	3 3/4	3 1/5
2/3	3 1/9	4 2/3	3 2/3	4 1/4
1/2	2 1/2	1 1/2	1 5/6	2 3/10

5.(e) Add

2hr 14min 20sec	5yd 2ft 6in	2hr 7min 30sec
5hr 50min 19sec	4yd 1ft 8in	1hr 9min 40sec
		3hr 5min 55sec

6.(a) Subtract

.852	.592	8.58	92.32	24.24
.364	.243	7.92	54.27	6.39

6.(b) Subtract

80,000	67,129	600,000	338,507
27,356	39,057	568,403	299,389

6.(c) Subtract

5/6	7/8	8	4 1/4	6 3/4
1/2	1/2	2 3/4	2 5/8	11/12

6.(d) Subtract

5 1/4	7 3/4	9 1/6	5 1/2	8
3 2/3	2 5/6	8 1/4	2 3/5	5/8

6.(e) Subtract

3hr 40min 10sec	5yd 2ft 2in	5hr 38min 12sec
2hr 38min 12sec	3yd 2ft 6in	3hr 38min 14sec

Appendix B (continued)

7.(a) Multiply

2 2/5 X 1 3/4 = ____ 2 1/4 X 2 2/3 = ____ 1 1/2 X 1 2/3 = ____

2 1/4 X 2 1/3 = ____ 1 1/5 X 3 3/4 = ____ 7/8 X 5 1/3 = ____

7.(b) Multiply

15.7	187	2.06	32.9	356	8.79
86	.75	9.7	.096	.095	9.5

7.(c) Multiply

48 X 3 1/6 = ____ 49 X 2 1/7 = ____ 36 X 2 1/12 = ____ 81 X 1 1/9 = ____

7.(d) Multiply

734	952	306	265	307	628
289	892	765	908	809	470

7.(e) Multiply

3yd 1ft 8in	2hr 30min 20sec	5yd 2ft 9in
4	6	4

8.(a) Divide

3 1/3 ÷ 1 2/3 = ____ 1 4/5 ÷ 2 7/10 = ____ 3 3/4 ÷ 2 1/2 = ____

8 ÷ 1 1/4 = ____ 7/8 ÷ 3/4 = ____ 3/4 ÷ 1 1/3 = ____

8.(b) Divide

99 ⟌ 34,155 365 ⟌ 74,825 278 ⟌ 88,960 59 ⟌ 20,709

8.(c) Divide

50 ⟌ 25 70 ⟌ 49 100 ⟌ 68 1,000 ⟌ 37

8.(d) Divide

23 ⟌ 853.3 .43 ⟌ 9546 2.4 ⟌ 7.536 .016 ⟌ 560

Appendix B (continued)

9.(a) Find the missing number

25% of 160 = ____ 33 1/3% of 210 = ____ 60% of 20 = ____

9.(b) and 9.(c) Find the missing number

6 = ____% of 48 8 = ____% of 40 28 = ____% of 32

9.(d) Find the missing number

10% of ____ = 8 75% of ____ = 9 12 1/2% of____ = 36

APPENDIX C

EXPERIMENTAL WORKSHEETS

#1

Add

49,687	3 7/8	3yd 2ft 6in
45,864	1 1/2	4yd 1ft 8in
36,970	4 2/3	
89,705	2 3/4	

Subtract

34,412	7 3/4	3hr 15min 36sec
10,503	2 5/6	1hr 15min 50sec

#2

Multiply

375	7/8 X 5 1/3 = ____	3.74	7hr 10min
697		.68	7

Divide

3 3/4 ÷ 2 1/2 = ____ 78 $\overline{)28,002}$ .016 $\overline{)560}$

#3

Find the missing number

5% of 340 =____ 24 is____% of 30 20% of____is 8 25 is____% of 30

#4

Add

$68.40	7 1/8	4gal 2qt 1pt
2.63	2 1/2	3gal 1qt 1pt
19.75	3 1/6	6gal 2qt 1pt
27.41		

Appendix C (continued)

#4 (continued)

Subtract

\$80.00 9.25	9 1/10 8 1/5	4hr 20min 2hr 40min 10sec

#5

Multiply

743 609	35 X 7 2/5 = ____	\$98.75 .65	4gal 3qt 1pt 6

Divide

3 1/3 ÷ 1 2/3 = ____	358 ⟌ 168,260	4 ⟌ 5hr 13min 31sec

#6

Find the missing number

4% of 650 =____ 16 is____% of 48 40% of 75 is____ 15% of 120 is____

#7

Add

237,720 468,314 934,205 583,699	5 2/3 6 3/4 2 5/12	21b 4oz 61b 12oz 41b 10oz

Subtract

326,080 182,432	52 2/5 28 1/2	41b 8oz 11b 9oz

Appendix C (continued)

#8

Multiply

951 × 906 = ____

5 1/2 X 2 1/4 = ____

56 X 7 5/8 = ____

41b 6oz × 6 = ____

Divide

6 2/3 ÷ 1 1/3 = ____

724 ⟌ 340,280

100 ⟌ $50

#9

Find the missing number

6% of 150 = ____

36 is ____ % of 48

25% of ____ is 75

52 is ____ % of 900

#10

Add

$20.69 + 3.84 + 14.26 + 25.40 = ____

3 5/6 + 2 1/4 + 7 1/12 = ____

4yd 2ft 7in + 1yd 1ft 1in + 3yd 2ft 5in = ____

Subtract

$30.00 − $7.25 = ____

9 1/2 − 6 3/4 = ____

9 7/15 − 4 8/25 = ____

5gal 2qt − 2gal 3qt 1pt = ____

#11

Multiply

4/5 X 8 1/3 = ____

48 X 6 7/8 = ____

$78.90 × .56 = ____

3hr 20min 10sec × 7 = ____

Divide

3 3/5 ÷ 1 4/5 = ____

1.68 ⟌ 621.6

247 ⟌ 125,476

Appendix C (continued)

#12

Find the missing number

2% of 350 =____ 27 is 75% of____ 16% of____is 336 20 is____% of 440

#13

Add

332,038	5 1/8	4 1/5
911,472	2 3/4	17 2/7
718,937	4 1/3	9 3/14
455,937		

Subtract

786,009	56 2/3	81b 7oz
425,237	29 3/4	61b 10oz

#14

Multiply

1 1/2 X 1 1/3 = ____ 168 508 64 X 8 3/8 = ____ $8.76 9.50

Divide

8 3/4 ÷ 1 3/4 = ____ 100 ⟌ $40 5 ⟌ 7hr 10min

#15

Find the missing number

6% of 150 =____ 36 is____% of 48 25% of____is 75 16 is____% of 40

Appendix C (continued)

#16

Add

\$20.49	5 1/8	21b 4oz
5.65	2 3/4	61b 9oz
14.35	4 1/3	101b 11oz
19.85		

Subtract

\$80.00	61 1/2	4gal 1qt
6.35	25 3/5	2gal 3qt 1pt

#17

Multiply

1 2/3 X 2 2/5 = ____ \$65.50 3.40 75 X 8 3/5 = ____ 4hr 30min 10sec 7

Divide

7 1/2 ÷ 1 1/2 = ____ 862 $\overline{)\,594{,}780}$ 1.59 $\overline{)\,922.2}$

#18

Find the missing number

25% of 160 =____ 8 = ____% of 40 10% of____= 8 100% of 175 =____

#19

Add

49,687	2 3/4	6hr 10min 20sec
45,864	4 2/3	5hr 15min 40sec
36,970	1 1/2	1hr 45min 10sec
89,705		

Appendix C (continued)

#19 (continued)

Subtract

80,000 27,356	9 1/6 8 1/4	10lb 6oz 4lb 9oz

#20

Multiply

265 908	7/8 X 5 1/3 = ____	53.7 3.74

Divide

8 ÷ 1 1/4 = ____	99 $\overline{)34,155}$	.35 $\overline{)5.6}$

#21

Find the missing number

60% of 20 =____ 150 = ____% of 200 75% of____ = 9 8% of 750 =____

#22

Add

422,165 673,798 897,524 586,049	4 2/3 5 1/4 3 7/12	4gal 2qt 1pt 3gal 1qt 1pt 6gal 2qt 1pt

Subtract

40.00 2.75	3 5/8 1 5/9	4hr 20min 2hr 40min 10sec

Appendix C (continued)

#23

Multiply

951
906

5 1/3 X 2 1/4 = ____

4gal 3qt 1pt
6

Divide

6 2/3 ÷ 1 1/3 = ____

724 ⟌ 340,280

5 ⟌ 6hr 15min

#24

Find the missing number

16 is____% of 40 12% of____is 48 5% of 340 = ____ 24 is____% of 30

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