AN EXPERIMENT IN TEACHING SIXTH-GRADE ARITHMETIC TO COMPARE THE RESULTS OF MODERN VERSUS TRADITIONAL METHODS

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

One of the criticisms of the modern mathematics program taught in many elementary schools today is that children are not being taught computational skills and problem-solving techniques adequately. Critics say that the pupils are taught to understand arithmetic, but that they do not acquire the skill to do it. Computational skills and problem solving still are necessary in our modern life. Are they being neglected in the contemporary or modern mathematics programs? This experiment was set up to provide a partial answer to this question.

I. THE PROBLEM

Statement of the problem. Which method of teaching mathematics, the modern or traditional, will result in greater gains in the skills of computation, in abilities to solve problems, in understanding of the concepts of arithmetic, and in enjoyment on the part of the students during the year in which the pupils are in the sixth grade of school?

Hypotheses. The following hypotheses were tested in this study:

1. There is no significant difference between children

taught in a modern mathematics program and those taught by the traditional type of program with respect to accuracy in computation.

2. There is no significant difference between children taught in the modern and those taught in a traditional type of mathematics program with respect to ability to solve verbal problems.

3. There is no significant difference between children taught in the modern as compared to those taught in a traditional type of mathematics program with respect to ability to understand the number system and its functions.

4. There is no difference in pupil interest in and enjoyment of mathematics whether they are taught by modern methods or traditional methods of mathematics.

II. THE NEED FOR THE STUDY

The new mathematics has created some problems, but the benefits outweigh the difficulties created, according to many authorities. It is extensive, deep-rooted, and not a "flash-in-the-pan" type of reform. Large sums of money have been spent and are being spent by foundations, the national government, and research organizations; and a great many mathematicians are involved. The claims and new proposals should be examined closely. One of the claims is that students taught under the new mathematics program will be able to think mathematically and not just computationally. A further claim is that if a child masters the modern mathematics program, he will have intellectual power and skill of recognized value.

The appearance of Sputnik, the first artificial satellite which was orbited by the U.S.S.R. on Oct. 4, 1957, brought the problem of mathematical instruction to the attention of the American public, who began to clamor for a new and better approach not only to mathematics but to other sciences. Of course, many educators had been aware of this problem long before this as demonstrated by the existence of committees and commissions which had been appointed to examine our mathematical progress at all levels.

The School Mathematics Study Group (SMSG), a national foundation for the improvement of mathematical education financed by the National Science Foundation, held its first conference in February, 1959, in Chicago. With Professor E. B. Begle of Yale University as executive director and 54 teachers, supervisors, psychologists, and university mathematicians in attendance, it was decided that a critical study of the elementary school mathematics program should be made. By the summer of 1960, a team of teachers, mathematicians, and mathematics educators had produced a complete course of study for fourth grade mathematics and sample units for grades five and six. These have been tested and are being revised for publication.[1]

The Greater Cleveland Mathematics Program was developed by the Educational Research Council of Greater Cleveland. It began working in 1959 with Dr. George H. Baird as its executive director. The program places its primary emphasis on thinking, reasoning, and understanding, instead of purely mechanical responses to situations. Its scope ranges from kindergarten to grade twelve.[2]

Other projects which have been developed are:

1. University of Illinois Arithmetic Project directed by Professor David Page which made use of smaller units of instruction with gifted children in grades four to six.[3]

2. The Madison Project under the direction of Professor Davis of Syracuse University, which has developed topics for grades three through eight with materials which work well in the hands of teachers whom he trains.[4]

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[1] National Council of Teachers of Mathematics, An Analysis of New Mathematics Programs. (Washington: National Council of Teachers of Mathematics, 1963), pp. 32-51.

[2] Ibid. pp. 10-15.

[3] Paul C. Rosenbloom, "What is Coming in Elementary Mathematics," Educational Leadership, XVIII (November, 1960), p. 97.

[4] National Council of Teachers of Mathematics, op. cit., pp. 21-24.

3. The Stanford Project under the direction of Professor Suppes, who has written books on sets for the kindergarten through the second grade, proceeds under the belief that all mathematics can be developed from the idea of sets and their operations.[5]

4. Hawley and Suppes of Stanford University (1958) developed geometry for primary grades which works well with teachers of average ability. They are now working on a unit in logic for gifted students in grades five and six.[6]

5. Professor F. E. Koehen, University of Minnesota, developed a unit on algebra in grade four which ordinary teachers can use.[7]

6. Minnesota Elementary Curriculum Project under the direction of Professor P. Rosenbloom, University of Minnesota, developed work for gifted children in grades five and six, and are now working on a science-mathematics program for kindergarten through ninth grade.[8]

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[5] United States Department of Health, Education and Welfare, Elementary School Mathematics, (Bulletin No. 13. Washington: Government Printing Office, 1963), pp. 74-78.

[6] *Ibid.* pp. 78-84.

[7] Rosenbloom, *op. cit.*, p. 98.

[8] United States Department of Health, Education, and Welfare, *op. cit.*, pp. 85-92.

Actually contemporary mathematics in the high schools began around 1850 when Boole wrote his Laws of Thought, a forerunner of modern symbolic logic. By 1875, the nature of the real number system was attacked by several mathematicians including Wesstross, Dedekind, and Cantor. In 1899, Hilbert's logical foundation of geometry established the basis of postulational methods, which has had a powerful influence on Twentieth Century mathematics.[9]

During the last 25 years, mathematicians have come to think of mathematics as a study of structures which can be used to arrive at solutions to problems which pervade every area of the modern world. However, as higher mathematics was developing these new patterns, arithmetic was being fragmentized into tiny items. One research study pointed out that to teach the addition of proper fractions, more than 80 different computational techniques must be taught. The role of the elementary teacher was conceived as having only to teach and drill these techniques in order to be a successful arithmetic teacher. Thus a difficulty in articulation developed between the elementary school and higher education.[10]

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[9] William L. Schaaf, "Mathematics as a Cultural Heritage," The Arithmetic Teacher, VIII (January, 1961), pp. 5-9.

[10] Henry Van Engen, "Twentieth Century Mathematics for the Elementary Schools," The Arithmetic Teacher, VI (March, 1959), pp. 71-76.

During the same time, the "social utility" movement was stressed. Mathematicians reject this approach today because one can not foresee at the present time what will be useful in the future. As mathematicians have become interested in the elementary school, they feel that children like mathematics for its own sake. When children understand it, they will apply it to satisfy their own needs.[11]

With increased automation, new demands are being made on our school curriculum. Automation tends to strengthen the demand for labor at a high level of skill and knowledge and weakens it at the lowest levels. In the past fifteen years, the need for unskilled labor has declined by seven per cent, while the total labor force has jumped eighteen percent. The precise skills needed by labor often can not be taught in schools; therefore education in science and mathematics must have a broad base. Students should be encouraged to develop their maximum capabilities and be ready for changes, as they will likely experience several occupational shifts or major changes in their occupations during their lifetime.[12]

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[11] Ibid. pp. 71-76.

[12] Howard L. Hurwitz, "What Shall We Teach About Automation?," Social Education, XXVII (October, 1963), pp. 301-304.

The average citizen today needs more mathematics than in the past. Routine work in business and industry is disappearing, so a truly mathematical education is needed for most categories of skilled and professional manpower. Eighty per cent of the bills before Congress involve science and mathematics which the lawmaker and citizen will not be able to comprehend unless he is scientifically and mathematically well-educated. The technological and scientific revolutions taking place today make it imperative that every pupil be given the opportunity to learn as much as he can about mathematics in order that he can participate effectively in our culture.[13]

Statistical thinking and machine computation are two other aspects of modern mathematics. Modern industry, offices, and other fields demand the use of these constantly. The machine computers, far from putting mathematicians out of work, frequently use 50 to 70 trained technicians and mathematicians to prepare problems for the machine. The number of trained mathematicians is woefully low today; this adds an additional demand on our schools, namely the early identification and training of future mathematicians.[14]

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[13] Paul C. Rosenbloom, "Mathematics K--14," Educational Leadership, XIX (March, 1962), 359-363.

[14] National Council of Teachers of Mathematics, Insights into Modern Mathematics (23rd Yearbook. Washington: National Council of Teachers of Mathematics, 1957).

Mathematics has a vertical structure both in organization and continuity so that a teacher must not teach as facts ideas which will be proven wrong later. For instance, to teach that one must always subtract smaller numerals from larger ones does not hold true when one uses negative numbers. Teachers must therefore know what past ideas have been presented and what future concepts and understandings will be expected of their pupils. Ideas are understood at each stage of a child's development according to his ability, and there is no end stage. Teachers must provide pupils with continually recurring but varied contacts with the fundamental principles of mathematics which lead them forward in a continuous spiral into higher mathematics. In the elementary grades, instruction can not be rigorously logical, but it can build concepts which are consistent and easily extended into more abstract ideas at a higher level.

Many high school teachers complain that pupils shy away from mathematics programs and consider them dull, difficult, or boring, because of unpleasant associations with arithmetic in the lower grades. However, after a decade of experimentation involving psychologists, mathematicians and teachers, it has been proven that children can and do enjoy learning subject matter which was traditionally thought too hard for them. Clark has predicted that six of the major aspects of the coming program in mathematics are:

1. Greatly improved scholarship of teachers in the nature or structure of arithmetic;
2. Deeper conviction in the public mind of the increasing significance of arithmetic in our culture;
3. Greater emphasis upon thinking and discovery in arithmetic learning;
4. More consideration of (and provision for) the implications of the wide range of ability in any age group;
5. Increased use of certain mathematical topics not at present widely included in the arithmetic curriculum;
6. Wider use of newer tools of learning.[15]

A great deal of effective teaching of mathematics is going on today and has gone on. Responsible mathematicians claim that more new mathematics has been discovered since 1900 than was known at that time. Today's teachers are faced with the problems of (1) seeking new and more effective mathods of improving their students' capacities to comprehend mathematical structures and concepts, (2) seeing that the mathematical heritage is preserved for the future, (3) creating an interest in mathematics which the student will enjoy for its own sake, and (4) choosing the content to be taught. (Just because a topic _can_ be taught does not prove that it _should_ be taught.)

Brownell, in the Tenth Year Book of the National Council of Teachers of Mathematics, gave the first well-developed statement of what he termed the "meaning theory"

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[15] John R. Clark, "Looking Ahead at Instruction in Arithmetic," _The Arithmetic Teacher_, VIII (December, 1961), pp. 388-389.

of arithmetic instruction which stressed teaching for "generalization" and "constructive thinking". He warned that educators must be aware of the progress made and take advantage of the good things, but at the same time, we must not discard all the old as necessarily bad.[16]

There is more than one way to improve an arithmetic program; therefore, teachers should be concerned if they are told that there is only one possible set of instructional materials, only one right method, only one way to organize the mathematical content, or that only one particular mathematical procedure or algorithm is the correct one to use. Educators have in the past, and still do use poor methods and materials, that should be corrected; but the goal should be to find various good means to improve the mathematics program. Teachers today must begin to participate in trying out and refining new ideas and materials. Because the old arithmetic has been and is an effective way to gain intellectual power and utilitarian tools, it is not wise to abandon it until content and teaching methods of the new mathematics programs have been proven superior.

The scope of the study. Because of the problem of poor articulation between the elementary and higher education and the difficulty of foreseeing the future needs of society, educators have seen the necessity of a change in

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[16] National Council of Teachers of Mathematics, The Teaching of Arithmetic. (Washington: National Council of Teachers of Mathematics, 1935), pp. 19-31.

the mathematics curriculum. Today many mathematicians, psychologists and education specialists are interested in this study, and many new programs have been suggested. However, these can not be accepted until they have proven their worth.

In this study an attempt will be made to determine by experimental methods which method -- traditional or modern -- better fulfills the needs of our modern society in mathematics. A questionnaire also will be used to try to determine any differences in interest and enjoyment which the use of a special method may engender.

III. DEFINITIONS OF TERMS

Arithmetic: (1) The art of computation with figures (the most elementary branch of mathematics). (2) The science of number. It deals with the rules, principles, and processes which regulate the uses of number and operations involving number and quantitative procedures.[17]

Mathematics: In addition to teaching the four basic operations in arithmetic, it includes a program which introduces concepts of algebra, geometry, measurement, graphing and statistics. It serves the needs of man as he tries to understand and manipulate his own environment, and at the same time extends conceptual insights and emphasizes structure.

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[17] Foster E. Grossnickle and Leo J. Brueckner, *Discovering Meanings in Arithmetic*. (New York: Holt, Rinehard, and Winston, 1963), p. 1.

Modern mathematics: (1) Modern mathematics is to classical mathematics as elementary algebra is to elementary arithmetic. . . A characteristic of modern mathematics is its attempt to be as general as possible. . . Modern mathematics does not replace classical mathematics. It generalizes it, supplements it, unifies it, and deepens our understanding of it. But classical mathematics in the form of arithmetic, analysis and geometry are as important as they ever were.[18] (2) Modern mathematics is an attempt to emphasize the "why" as much as the "how", to develop a concept of mathematics as a unified structure, to teach some topics at an earlier grade than was formerly thought possible, and to allow children to discover relationships for themselves. It assumes that learning takes place better by first gaining an "insight" into the value of the total process.

Questionnaire: A questionnaire is a highly-structured interview conducted with pencil and paper which saves time and attempts to gather factual data pertinent to the question being studied.

Experiment: A method used to discover the truth by means of using a control and an experimental group in which all the factors are controlled as much as possible except the one being tested.

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[18] Irving Adler, "The Changes Taking Place in Mathematics," The Mathematics Teacher, LV (October, 1962), pp. 441-451.

IV. PROCEDURAL OUTLINE

Two groups composed of three classes of sixth-grade pupils were designed for experimental purposes. A control group which was taught traditional arithmetic by traditional methods and an experimental group which was taught modern mathematics by a modern approach formed the samples used.

The control group used Silver-Burdett's Making Sure of Arithmetic (1958) as its text, which and school district has been using in all its classes. The experimental group used Silver-Burdett's Modern Arithmetic Through Discovery (1963).

The control group and experimental group were tested three times during the year in order to evaluate their achievements and any changes in attitudes. Differences in I.Q.s, chronological age and achievement were not statistically significant at the beginning of the experiment.

Plan of the paper. In chapter II appears a review of studies which are similar to this one; in chapter III a description of the experiment, materials used, and methods of measurement is given to clarify the construction of the experiment; chapter IV describes the progress of the experiment; chapter V gives the results of the experiment; and chapter VI reports the summaries and conclusions of the experiment.

CHAPTER II

REVIEW OF LITERATURE

A great deal has been written about the need for curriculum revision in mathematics, and many commissions, projects and individuals are studying the problem and making contributions which they feel will be of value. Many programs are being tried out in an experimental fashion, but little information has been published as to the results of these experimental studies. Often, too, the results are inconclusive as to the merits of the programs. This is, in part, due to the newness of the material, the difficulty of getting the studies published and the lack of standardized tests to test the achievement of pupils taught under the modern mathematics programs.

Several of the centers conducting studies of this nature have been contacted, but with limited success due to the fact that the studies are not yet completed.

I. COMPARISON ON THE BASIS OF ACHIEVEMENT

An investigation was conducted at the Minnesota National Laboratory (1963) of the achievement of ten classes using fourth grade School Mathematics Study Group (SMSG) material compared to that of ten classes of fourth grade pupils using conventional fourth grade texts. When the mathematics test of the _Sequential Tests of Educational Progress_ was administered, no statistically significant difference in mathematical achievement was found between the two groups.[1]

A similar study by Weaver (1963) showed that fourth and fifth grade pupils who used SMSG texts during one school year made mean gains in problem solving and computation which were equal to or higher than the gains one would normally expect in terms of grade equivalence on a standardized traditional arithmetic test.[2]

Peck (1963) studied two matched samples of sixth grade pupils. One group studied selected contemporary topics, and the other group studied the traditional mathematics of the grade. When they were tested on a standardized achievement test, they showed no statistically significant difference in arithmetic reasoning and computation.[3]

Ruddell (1962) reported that seventh grade pupils who studied in an accelerated mathematics program of modern content received scores on a standardized achievement test as high as or higher than those of a similar group who were

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[1] Minnesota National Laboratory, Evaluation of SMSG Text--Grade 4 (Reports, Newsletter No. 13. Stanford, California: School Mathematics Study Group, 1963), pp. 8-10.

[2] J. Fred Weaver, "Student Achievement in SMSG Classes, Grades 4-5," (Reports. Newsletter No. 15. Stanford, California: School Mathematics Study Group, 1963), pp. 3-8.

[3] Hugh I. Peck, "An Evaluation of Topics in Modern Mathematics," The Arithmetic Teacher, X (May, 1963), pp. 277-279.

taught traditional mathematics.[4]

Treadway and Hollister (1957-59), in an attempt to discover which approach would produce better results in teaching basic concepts of percentage to seventh grade pupils, worked with 552 pupils in 11 experimental and control groups from four different schools in Wyoming. The experimental and control groups were alternated the second year. Two tests were devised and used for the two groups. The first was given at the end of the 20 day teaching period, and the second, a retention test, was given 30 teaching days after the first test. Statistical computations were based on these plus the intelligence scores computed from the California Tests of Mental Maturity, and the sex of the pupil. The results of the tests showed that the total experimental group had scores significantly higher than did the control group on the first test. This also was true of all levels of I.Q. (Under 96, IQ 96-115, and IQ over 115). On the retention test those of low IQ showed no significant difference between the methods used, those with an IQ between 96 and 115 did significantly better in the experimental group, and those with an IQ above 115 showed no significant difference. The experimenters felt that this might be due to a poor test.

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[4] Arden K. Ruddell, "The Results of a Modern Mathematics Program," <u>The Arithmetic Teacher</u>, IX (October, 1962), pp. 330-335.

The scores on the initial test indicated that the group with the high IQs might be able to master the three cases of percentage in less than the 20 day teaching period.[5]

Cassel and Jerman (1963) reported on an experiment involving four classes of seventh grade pupils consisting of 121 individuals, two classes of eighth grade pupils consisting of 63 individuals, and three classes of eighth and ninth grade algebra classes consisting of 78 pupils. The seventh grade groups ranged in IQ from 95-142, and the eighth grade had an IQ range of 88-132, and the eighth and ninth grade algebra classes ranged in IQ from 105-140. These pupils' test scores were matched with the test scores of other pupils who were taught traditionally and who had the same IQ taken from the <u>California Test of Mental Maturity</u>, the same sex, and were in the same grade in school. The experimental group studied SMSG material, while the other group continued to study traditional material. The experiment was conducted in Lampoc, Calif. where the teachers in the SMSG program were given in-service training for a semester and attended the National Science Foundation Institute at the University of California on SMSG theory and methodology. All teachers in both groups were rated as average or above average by their principals. Students in the SMSG group were average or better

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[5] D. C. Treadway and C. E. Holister, "An Experimental Study of Two Approaches to Teaching Percentage," <u>The Arithmetic Teacher</u>, X (December, 1963), pp. 491-495.

in IQ, showed an aptness for mathematics in other classes, or had expressed a desire to participate in the program. The Cooperative Mathematics Test, Arithmetic, Form A, 1962, and The Cooperative Algebra Test, Algebra I, Form A, 1962, were used for evaluation. Both tests are concerned primarily with traditional concepts of mathematics.

The results of the tests showed:

1. The seventh grade median from all scores showed statistically better scores for pupils in the SMSG program as compared to those in the traditional arithmetic (beyond the .01 level of confidence).

2. The eighth grade pupils enrolled in SMSG instruction did significantly better than those enrolled in the traditional arithmetic (beyond .01 level of confidence).

3. The pupils in the algebra class also did significantly better in the SMSG program as compared to the traditional mathematics program. The author states:

> "Pupils enrolled in SMSG instruction for all three groups had statistically high arithmetic and algebra scores, respectively, at the .01 level of confidence than matched pupils enrolled in the traditional program."[6]

Bowman criticises this statement and the whole experiment. He claims that there is no such evidence produced

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[6] R. N. Cassel and M. Jerman, "A Preliminary Evaluation of SMSG Instruction in Arithmetic and Algebra for Seventh, Eighth, and Ninth Grade Pupils," <u>California Journal of Educational Research</u>, XIV (November, 1963), pp. 202-207.

for grade seven and inferentially none for grades eight and nine. He felt that the matching was poorly done in that the IQ S.D.s are significantly different in the seventh grade and were not given in the other two grades. He also points out that at all grades the IQ of the SMSG group is higher. The pupils in the SMSG group were carefully chosen and he feels that this did not happen in the traditional group. He further points out that the SMSG students also were higher significantly in reading and language achievement indicating that they were substantially superior to the controls.[7]

In a rejoinder, Cassel says that the study purports to have shown that SMSG instruction offered more for the above-average student than traditional mathematics. The achievement tests were administered near the end of the study and show that mathematics instruction is not an isolated phenomenon. He feels it encouraging that both the reading and language scores were higher for students who receive SMSG instruction, and further states that:

> "... one would have to conclude that the newer approaches to mathematics are no longer a "new fad" or "cure all", but really a long awaited for "break-through" in our approach to the guidance of learning activities in the area of mathematics. This, as an educator, I would be sure of in the absence of any statistical data

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[7] H. A. Bowman. "Reply," California Journal of Educational Research, XV (March, 1964). pp. 52-55.

to support what I have heard administrators throughout the country say."[8]

Earhart experimented in Drayton Plains, Michigan, with two approaches to primary mathematics to discover if there was a significant difference in mean "reasoning" grade equivalent scores and the mean "fundamental" grade equivalent scores on achievement tests when the two groups were compared. Group A consisted of 216 third grade students who had studied new mathematics for two years and two months. Group B had 872 pupils with no experience in modern mathematics. Group A's median IQ was 107.8 while Group B's median IQ was only 105.2. This constituted a significant difference at the five per cent level. The <u>California Achievement Tests</u> were administered in January, 1961. His conclusion was that students in the new mathematics program performed significantly better in fundamentals, but there was no statistical difference in reasoning.[9]

Lyda and Taylor (1946) found no statistical difference in arithmetic achievement between 60 sixth graders in the experimental group as compared to the control group. However, there was some growth in understanding of the decimal

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[8] R. N. Cassel, "Rejoinder," <u>California Journal of Educational Research</u>, XV (March, 1964), p. 55.

[9] E. Earhart, "Evaluating Certain Aspects of a New Approach to Mathematics in Primary Grades," <u>School, Science, and Mathematics</u>, LXIV (November, 1964), pp. 715-720.

numeration system by the experimental group who were taught modular arithmetic.[10]

Hollis (1946) found that following work with a base other than ten, one fourth grade class showed an increase on their median and mean scores on the Metropolitan Achievement Test.[11]

In a comparison of pupil's attitude with achievement in arithmetic, Bassham, Murphy and Murphy found an important difference in mean scores in mastery of fundamental concepts to exist between pupils classified in the upper two-fifths and those in the lower two-fifths of a distribution attitude score.[12]

In a study to compare the effectiveness of teaching first and second grade mathematics by the Cuisinaire--Gattegno method as compared to a traditional method, Loye Y. Hollis (1961) worked with nine classes of first grade pupils. Further instruction was given the next year. After two years, three

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[10] W. J. Lyda and Margaret D. Taylor, "Facilitating and Understanding of the Decimal Numeration System Through Modular Arithmetic," The Arithmetic Teacher, XI (February, 1964), pp. 101-103.

[11] Loye Y. Hollis, "Why Teach Numeration?" The Arithmetic Teacher, XI (January, 1964), pp. 94-95.

[12] Harrell Bassham, Michael Murphy and Katherine Murphy, "Attitude and Achievement in Arithmetic," The Arithmetic Teacher, XI (February, 1964), pp. 66-72.

tests were administered: (1) achievement, (2) traditional test to measure concepts and skills taught in traditional mathematics, and (3) mathematics test designed to measure concepts and skills taught in experimental programs. Instruction was given for 25 minutes a day. The results showed that children instructed in the experimental classes did significantly better on all tests at the end of the second year. This included all levels of intelligence.[13]

An experiment by Hazel M. Tompkins, a graduate student at the University of Minnesota Duluth, showed that three classes of 83 pupils in Owatonna, Minnesota, of sixth-grade students taught with materials prepared by the Greater Cleveland Mathematics Program scored as well as children taught by a traditional method in a teacher-made test based on traditional computation, concepts, and problem solving. The control group was composed of four classes of 98 pupils who were taught traditional sixth-grade mathematics in Albert Lea, Minnesota.[14]

A comparative study made by Milan S. Karich at the Hermantown public schools, of two classes of 25 students each

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[13] Loye Y. Hollis, "A Study to Compare the Effects of Teaching First and Second Grade Mathematics by the Cuisinaire--Gattegno Method with a Traditional Method," <u>School, Science, and Mathematics</u>, LXV (November, 1965), pp. 683-687.

[14] Hazel M. Tompkins, "Achievement in Arithmetic by Students Taught Traditionally Compared With Students Taught by a Modern Mathematics Program" (unpublished Master's thesis, The University of Minnesota, Duluth, 1963).

in algebra, showed that the experimental group using a modern curriculum and the control group using a traditional curriculum learned approximately an equal amount of algebra. The experimental group did as well as the control group in five of the six tests which were based on traditional algebra. On the Midwest High School Achievement Examination the control group showed a significant gain. No conclusive evidence was found to indicate whether more interest and enthusiasm is generated in students by one method than by the other.[15]

II. COMPARISON ON THE BASIS OF ATTITUDES AND INTERESTS

Lindgren, Silva and others studied the attitude of the child toward problem solving and observed it to be positively and significantly correlated to arithmetic achievement for children in the four-year elementary school in Brazil. Problem solving attitude was also correlated positively, but not significantly, with marks in arithmetic.[16]

Poffenberger and Norton made a study of a class of fourth grade pupils' attitudes toward mathematics. They concluded that students who liked traditional mathematics also

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[15] Milan N. Karich, "A Comparative Study of Two Approaches of Teaching First Year Algebra," (unpublished Master's thesis, The University of Minnesota, Duluth, 1962).

[16] Henry Clay Lindgren, Ina Silva, Itallia Faraco, and Nadir Saldanha Da Rocha, "Attitude Toward Problem Solving as a Function of Success in Arithmetic in Brazilian Elementary Schools," Journal of Educational Research, LVIII (September, 1964), pp. 44-45.

liked modern mathematics. Furthermore, there appeared to be no relationship between achievement and attitude towards mathematics, and very little difference was found between boys and girls in their attitude toward arithmetic.[17]

Rowland and Inskeep in their study of Cajon Valley Union School District (1963)[18] and Mosher (1952)[19] both found that children in the elementary grades tend to rank arithmetic in first place in subject preference.

Chase (1949)[20] and Sister Josephine (1959)[21] differed from this in that they found arithmetic the second best-liked subject.

Of the least-liked subjects, Sister Josephine[22] found that arithmetic was rated first; whereas Rowland and Inskeep[23]

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[17] Thomas Poffenberger and Donald Norton, "Factors in the Formation of Attitudes Toward Mathematics," Journal of Educational Research, LII (January, 1959), pp. 171-176.

[18] Monroe Rowland and James Inskeep, "Subject Preferences of Upper Elementary School Children in Cajon Valley Union School District," California Journal of Educational Research, XIV (September, 1963), p. 189.

[19] Howard H. Mosher, "Subject Preferences of Girls and Boys," School Review, LX (January, 1952), pp. 34-38.

[20] Linwood W. Chase, "Subject Preferences of Fifth Grade Children," Elementary School Journal, L (December, 1949), pp. 204-211.

[21] Sister Josephine, "A Study of Attitudes in the Elementary Grades," Journal of Educational Sociology, XXXIII (October, 1959), pp. 56-60.

[22] Ibid.

[23] Rowland and Inskeep, loc, cit.

found that it was ranked fifth. Mosher[24] found that arithmetic at the junior high level was ranked as the best liked, but in senior high school it was reduced in rank to third place. However, on a list of least-liked subjects, arithmetic ranked third in both junior and senior high school.

Fedin (1958)[25] found that an attitude for or against arithmetic may be developed as early as grade three. However, Dutton (1962)[26] found that grades four through eight are the most crucial years to develop attitudes of like or dislike for arithmetic.

II. SUMMARY

These studies seem to support the hypothesis that those pupils studying modern mathematics do not sacrifice gain in either problem solving or computational ability. Also the students were all tested by standardized tests that tend to measure important aspects of traditional mathematics. Many aspects of modern mathematics are not being tested as a result. Many more studies will have to

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[24] Mosher, loc. cit.

[25] Peter Fedin, "The Role of Attitude in Learning Arithmetic," The Arithmetic Teacher, V (December, 1958), pp. 304-310.

[26] Wilbur H. Dutton, "Attitude Change of Prospective Elementary School Teachers Toward Arithmetic," The Arithmetic Teacher, IX (December, 1962), p. 421.

be made and tests standardized to test the results of modern teaching before educators would be justified in discarding the old arithmetic for the newer programs.

In this study the groups will be tested by a standardized test to determine if they can compute accurately and solve problems adequately, but it also will try to test understandings and appreciations and to determine whether any change has taken place in attitudes toward mathematics.

The next chapter deals with the design of the problem.

CHAPTER III

EXPERIMENTAL DESIGN

The purpose of this experimental study was to compare the relative degrees of effectiveness of the modern and traditional approaches to the teaching of sixth grade mathematics. The experiment was conducted in the Grand Rapids School District using three rural and three urban schools. The district was contemplating a shift into modern mathematics and already had begun teaching it in the first two grades. A course in modern mathematics had been taken by all teachers in the first three grades in the fall of 1963, and a similar course was conducted for the teachers in the district in grades four through six in the fall of 1964. This in-service training was to acquaint the teachers with the principles of modern mathematics and to prepare them for a gradual change from a traditional type of teaching of mathematics to a modern program. It was planned that one grade would be changed per year starting with the first grade until all six grades would be studying modern mathematics.

I. EQUATING THE TWO GROUPS

Miss Catherine Walter, the urban supervisor, and Mr. M. C. Kruger, rural supervisor, picked the classes which were to be included in the experiment so that each class would have approximately the same number of students. The classes then were assigned at random as to which would be taught modern mathematics (the experimental group), and which were to continue in the traditional methods (the control group) which were then in use in the district.

The number of children involved in the experiment at the start was 84 in each division, making a total of 168. Due to moving and other factors, this number was reduced in May to 81 in the experimental group and 77 in the control group, making a total of 158 pupils. The experimental group consisted of two rural schools and one town school, while the control group was composed of two urban schools and one rural school.

The comparison of chronological ages is presented in Table I.

TABLE I

COMPARISON OF CONTROL AND EXPERIMENTAL GROUPS
ON THE BASIS OF CHRONOLOGICAL AGE
(EXPRESSED IN YEARS AND MONTHS)

Date: 9-1-64

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	11.45	.45		D	23	11.74	.57	
B	30	11.61	.48		E	28	11.63	.45	
C	24	11.76	.41		F	33	11.62	.40	
Total	84	11.61	.46	.05	Total	84	11.65	.47	.05

Comparison of Composite Means
Difference of Means = .04
SE difference...... = .07
t.................. = .56

This very low value of the critical ratio "t" indicates that the age differences between the two groups was not significant.

Explanation of t-value. Statisticians have shown that when the t-value (t equals the difference of the means divided by the standard error of the difference) is based upon a chance difference between pairs of samples taken from the same population, the t tends to be distributed in a normal distribution curve if the number of cases in the sample is at least 30. The value of t then may be evaluated in terms of probability. Five per cent of the time a variation as large as 1.96 would be due to chance if the number in the sample is 121 or less. If the number in the sample is 121 or less, a t as large as 2.58 would reduce the chance factor to one per cent.

Most investigators accept the null hypothesis, that there is no difference between the true means of the samples being compared, when t is less than 1.96. In this study, the differences were considered significant if the t-values were larger than 1.96.

Comparison on the basis of intelligence. All of the children in the Grand Rapids School District are tested by the supervisors at the beginning of the first, fourth, and sixth grades for intelligence. In August the Lorge-Thorndike Verbal and Non-Verbal Intelligence Tests were administered.

Table II compares the experimental and the control groups on the basis of their scores on the verbal battery in August, 1964.

TABLE II

COMPARISON OF INTELLIGENCE QUOTIENTS OF
EXPERIMENTAL AND CONTROL GROUPS
BASED UPON LORGE-THORNDIKE INTELLIGENCE TESTS
VERBAL BATTERY, AUGUST, 1964

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	106.35	14.10		D	23	104.83	15.15	
B	30	112.50	15.85		E	28	110.75	15.75	
C	24	108.05	15.45		F	33	110.65	11.50	
Total	84	109.00	15.40	1.69	Total	84	109.10	14.30	1.57

Comparison of Composite Means
Difference of Means = .10
SE of difference... = 2.31
t.................. = .04

The composite mean intelligence quotient for the experimental group was found to be 109.00 while that of the control group was 109.10. Since the t-value was only .04 it can be said that there was no significant difference at the five per cent level.

Table III compares the two groups on the basis of intelligence quotients on the non-verbal battery in August, 1964. Here the difference in the means is .71 with the experimental group having a slightly higher mean of 104.14 as compared to the control group composite mean of 103.43.

TABLE III

COMPARISON OF INTELLIGENCE QUOTIENTS OF EXPERIMENTAL AND CONTROL GROUPS BASED UPON LORGE-THORNDIKE INTELLIGENCE TESTS NON-VERBAL BATTERY, AUGUST, 1964

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	101.50	10.85		D	23	100.04	11.30	
B	30	104.33	11.90		E	28	105.75	12.20	
C	24	107.21	14.90		F	33	103.81	9.90	
Total	84	104.14	12.65	1.39	Total	84	103.43	11.30	1.24

Comparison of Composite Means
Difference of Means = .71
SE of difference... = 1.86
t................. = .38

Since the t-value is only .38, it is evident that there is no significant difference at the five per cent level of significance. The two groups were therefore assumed to be equated in intelligence.

Comparison on the basis of achievement. All of the children in the Grand Rapids School District are tested in the fall of the year in achievement in basic school subjects. The Iowa Test of Basic Skills, Form II, was administered in the various classrooms by the teachers during the week of September 14, 1964.

Table IV compares the two groups with respect to the results on the vocabulary test.

TABLE IV

INITIAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF READING-VOCABULARY (IOWA TEST OF BASIC SKILLS), SEPTEMBER, 1964

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	6.60	1.37		D	23	6.53	1.73	
B	30	7.67	1.65		E	28	7.29	1.65	
C	24	6.95	1.62		F	33	7.67	1.33	
Total	84	7.08	1.56	.17	Total	84	7.13	1.60	.18

Comparison of Composite Means
Difference in the Means = .05
SE of difference....... = .25
t..................... = .20

The difference in the composite means is only .05 points. The t-value of .20 indicates that there is no significant difference at the five per cent level.

Table V shows the comparison of the classes and the composite mean scores in reading comprehension. The difference in the composite means is .01 points, and the t-value of .04 shows that there is no significant difference at the five per cent level. As the ability to use vocabulary correctly and to read with comprehension is necessary in many mathematical problems, the results of these two tests (vocabulary and comprehension) were considered to be of utmost importance in equating the groups.

TABLE V

INITIAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF READING-COMPREHENSION (IOWA TEST OF BASIC SKILLS), SEPTEMBER, 1964

EXPERMENTAL					CONTROL				
CLASS	N	$\overline{X}$	SD	SE_{X1}	CLASS	N	$\overline{X}$	SD	SE_{X2}
A	30	6.72	1.20		D	23	6.29	1.40	
B	30	7.43	1.57		E	28	7.25	1.43	
C	24	7.18	1.70		F	33	7.53	1.22	
Total	84	7.10	1.52	.17	Total	84	7.09	1.43	.16

Comparison of Composite Means
Difference in the Means = .01
SE of difference....... = .23
t...................... = .04

Table VI shows the comparison of the two groups in English achievement. This subtest of the Iowa Test of Basic Skills tests the pupil's knowledge of spelling, capitalization, punctuation, and grammar. The two groups show a difference of means of .14 points. The t-value of .52 indicates that there is no significant difference between the two groups at the five per cent level.

TABLE VI

INITIAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF ENGLISH ACHIEVEMENT (IOWA TEST OF BASIC SKILLS), SEPTEMBER, 1964

EXPERMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	6.85	1.40		D	23	6.96	1.70	
B	30	8.22	1.68		E	28	7.54	1.67	
C	24	7.37	2.09		F	33	8.02	1.32	
Total	84	7.49	1.82	.20	Total	84	7.63	1.61	.18

Comparison of Composite Means
Difference in the Means = .14
SE of difference....... = .27
t...................... = .52

In Table VII the two groups are compared in the test results obtained from the *Iowa Test of Basic Skills* in Work--Study Skills. This subtest includes items in the interpretation of graphs, the use of the dictionary, encyclopedia and other reference books, and tests the ability to read and interpret maps.

The difference in the composite means is .04. The t-value of .22 shows that there is no significant difference at the five per cent level between the two groups on this subtest.

TABLE VII

INITIAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF WORK-STUDY SKILLS (IOWA TEST OF BASIC SKILLS), SEPTEMBER, 1964

EXPERMENTAL					CONTROL				
CLASS	N	$\overline{X}$	SD	SE_{X1}	CLASS	N	$\overline{X}$	SD	SE_{X2}
A	30	7.10	1.06		D	23	6.68	1.13	
B	30	7.58	1.10		E	28	7.27	1.03	
C	24	7.12	1.49		F	33	7.61	.93	
Comp.	84	7.28	1.23	.14	Comp.	84	7.24	1.09	.12

Comparison of Composite Means
Difference in the Means = .04
SE of difference....... = .18
t...................... = .22

Table VIII shows a comparison of the experiemntal and the control groups on the basis of scores in arithmetic concepts. This tests primarily the ability of the pupil to add, subtract, multiply, and divide with whole numbers and common and decimal fractions.

The difference in the composite means was .04. The t-value of .29 indicates that the two groups showed no significant difference at the five per cent level at the initial testing period. This test was repeated in January and May to determine if either group showed a greater growth in the ability to compute accurately and with greater understanding of the algorithm required.

TABLE VIII

INITIAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF ARITHMETIC CONCEPTS (IOWA TEST OF BASIC SKILLS), SEPTEMBER, 1964

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	6.60	1.48		D	23	6.53	.93	
B	30	6.90	.85		E	28	6.77	.99	
C	24	6.85	1.00		F	33	6.85	.73	
Comp.	84	6.78	.91	.10	Comp.	84	6.74	.89	.10

Comparison of Composite Means
Difference in the Means = .04
SE of difference....... = .14
t..................... = .29

Table IX shows a comparison of the means of the experimental and the control groups on the problem solving portion of the *Iowa Test of Basic Skills* administered in September, 1964. In this test, the pupil was required to read a problem, decide what the question was, determine the method of solving the problem, determine which information given was pertinent to the correct solution, and then compute accurately to reach a correct solution.

The test was administered again in January and May to determine if either group showed a greater growth in the ability to solve problems with skill and accuracy.

TABLE IX

INITIAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF PROBLEM SOLVING (IOWA TEST OF BASIC SKILLS), SEPTEMBER, 1964

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	6.67	.96		D	23	6.29	.97	
B	30	6.98	1.17		E	28	6.72	1.13	
C	24	6.95	1.22		F	33	6.83	.79	
Comp.	84	6.86	1.12	.12	Comp.	84	6.65	.99	.11

Comparison of Composite Means
Difference in the Means = .21
SE of difference....... = .16
t...................... = 1.31

The difference in the composite means is .21. The t-value of 1.31 indicates that the two groups show no significant difference at the five per cent level. However, each class in the experimental group is slightly superior in means to the matched class in the control group.

Table X is a comparison of the means of the experimental and control groups in the Iowa Test of Basic Skills of the composite tests which include vocabulary, reading, language, work-study skills, and arithmetic.

The difference in the means was .02. The t-value of .11 shows that there is no significant difference between the two groups at the five per cent level on the composite test results.

TABLE X

INITIAL COMPARISON OF EXPERIEMNTAL AND CONTROL GROUPS ON THE BASIS OF COMPOSITE IOWA TEST OF BASIC SKILLS, SEPTEMBER, 1964

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	6.75	1.00		D	23	6.57	1.23	
B	30	7.53	1.26		E	28	7.24	1.26	
C	24	7.05	1.46		F	33	7.37	1.01	
Comp.	84	7.12	1.28	.14	Comp.	84	7.10	1.21	.13

Comparison of Composite Means
Difference in the Means = .02
SE of difference....... = .19
t...................... = .11

Comparison on the basis of understanding of the number system. Because there was no standardized test available to test for understanding of the number system, a test was prepared by the experimenter. It was administered to all children included in the six classes by Mr. George Stockman, Co-ordinator of Elementary Education, during the last week in August, 1964. This test was scored by the experimenter and was not seen by any of the teachers involved in the experiment at any time.

The results of this comparison are shown in Table XI.

TABLE XI

INITIAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF TEST IN UNDERSTANDINGS AUGUST, 1964

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	30.33	7.70		D	23	28.09	8.05	
B	30	30.50	6.95		E	28	28.96	8.40	
C	24	33.67	8.00		F	33	33.51	6.70	
Comp.	84	31.35	7.65	.84	Comp.	84	30.57	8.10	.89

Comparison of Composite Means
Difference in the Means = .78
SE of difference....... = 1.22
t..................... = .64

As may be seen, the initial comparison of the two groups in understandings show no significant difference at the five per cent level (t = .64).

Socio-Economic Status. An assumption was made that the socio-economic status of both groups is similar. It is reasonable to believe this, since the schools are scattered throughout the school system and are representative of various neighborhoods and environmental factors. Also, the classes were picked to include both rural and urban areas and were selected mainly to equate the size of the classes. They then were assigned at random to either the experimental or control group.

The Teacher Factor. It was further assumed that the factor of teacher differences had been eliminated as far as possible because all of these were successful teachers with many years of experience in the school district.

II. MATERIALS USED

The control group used Silver-Burdett's textbook, Making Sure of Arithmetic (1958) for the first half-year. This text provides work to build vocabulary and basic number concepts such as: (1)knowledge of place values; (2)the concept of one million; (3)understanding Roman numerals; (4)understanding the rounding off of numbers to the nearest ten, hundred, thousand, and million; and (5)a knowledge of measurements. Computational skills are developed to enable the pupil to work efficiently in addition, subtraction, multiplication, and division of whole numbers and common and decimal fractions. In measurement, the students are taught to compute area and perimeter and to add and subtract denominate numbers. Finally, problem solving is taught, using problems within the child's understanding to enable him to solve one-and two-step problems dealing with whole numbers and common and decimal fractions.

The experimental group used Silver-Burdett's textbook, Modern Arithmetic Through Discovery (1963) for the whole year. The control group used this text for the second half of the school year. This text develops concepts covering much the same material as the older text, but with an imphasis on the children's discovery for themselves of definite patterns which would lead them to formulate a rule which would apply to other situations. More time is spent on the number line to help them understand place value. Other bases are introduced and precision in vocabulary is stressed. The associative and commutative laws of multiplication and addition and the distributive laws are developed. The identity numbers one geometry, and precision in measurement are developed.

No attempt was made to keep the pupils in the different divisions on the same pages or topics, as it was felt that the individual teacher would know his own class needs and could decide how to meet them. Nor was any limit made as to the use of other materials or homework which the individual teacher might decide to use. However, the teachers in the traditional classes were instructed to teach according to the show-tell and drill method with only as much understanding stressed as the textbook recommended. The subject matter also was limited to what was presented in the text, although more drill was permissible if the teacher wished to use it. In the modern method classes, the teachers were asked to use the discovery or inductive method, concise and explicit terminology, and the new subject matter which was presented in the text. This could be supplemented in any way or with other material the individual teacher might want to use.

III. APPRAISAL OF END-RESULTS OF EXPERIMENT

The *Iowa Test of Basic Skills* was administered in

January and May in arithmetic computation and arithmetic problem solving by the individual teachers to measure the students' progress and achievement. These tests measure important aspects of traditional mathematics.

The _Test in Understandings_, designed by the experimenter, also was administered in January and May. These were administered by the Co-ordinator of Elementary Education in the Grand Rapids School District. All tests were scored by the experimenter. The test was written in an attempt to measure growth in understanding of the number system. However, the test was written in a vocabulary which the children in the control group would be able to understand. Therefore, he should be able to answer the questions correctly if he understood the principles involved.

At the same time as the test in understandings was administered, each child was given a questionnaire to fill out. This non-objective scale was used to attempt to determine if any change in attitudes or interests took place during the course of the experiment in the field of mathematics. Exumples of the _Test in Understandings_ and the _Attitude Inventory_ will be found in the Appendix.

IV. SUMMARY

In this chapter the purpose of the study and its setting were delineated. The in-service training of the teachers was described. The experimental and control groups were shown to be of the same chronological age, and no significant differences were found in intelligence or achievement in the basic school subjects. The materials to be used were described, and the methods of measurements were outlined. In the next chapter, the pregress of the experiment will be traced.

CHAPTER IV

THE EXPERIMENT

An experiment was devised to determine if there was any significant difference in the results obtained in computation and problem solving abilities, understanding of the number system, and the development of appreciations when two methods of teaching are employed, the traditional and the modern approach. Permission to use this experiment in the Grand Rapids sixth grade mathematics program was obtained from Superintendent of Schools M. L. Malmquist. An interview with the two supervisors of elementary education and the co-ordinator was arranged next to outline the plan of the experiment and to enlist their help in picking the classes to be involved and in the administering of the Understandings Test. The experiment was to be initiated in the fall of 1964 with six classes included in the study.

I. CONSTRUCTING THE TEST

In writing the test in Understandings, a suggested test in The Arithmetic Teacher,[1] sixth grade textbooks (both traditional and modern), and A Guide for Instruction in

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[1] Frances Flournoy, Dorothy Brandt, and Johnnie McGregor, "Pupil Understanding of the Numeration System," The Arithmetic Teacher, X (February, 1963), pp. 88-92.

Arithmetic; Curriculum Bulletin No. 3 were examined in an effort to make the test representative of understandings that sixth grade mathematics should be expected to produce in a year's study. The final draft of the test consisted of 45 multiple-choice questions and 25 true-or-false statements. A copy of the test may be seen in the Appendix.

Of the 45 multiple-choice questions, 22 of them dealt with the understanding of the number system and place value; (1,2,4,5,7,8,14,15,17,18,20,23,24,26,27,29,30,33,34,35,37 and 39); three with rounding off numerals (3,21,and 31); three with measurement (9,38 and 43); two with power notation (10and 29); two with Roman numerals (11 and 12); two with multiplication of fractions, common or decimal (13 and 19); six with understanding of common and decimal fractions (16,28,36,41,44 and 45); two with percentage (22 and 25); five with multiplication by ten, one hundred, and one thousand (10,15,24,29 and 32); and one with division of decimal fractions (40).

In the 25 true-or-false statements, six showed understanding of the number system (1,2,15,16,17 and 19); one in measurement (6); three in Roman numerals (3,4, and 5); two in understanding decimal and common fractions (18 and 23); four on the commutative law (7,8,9,and 10); four on the associative law (11,12,13 and 14); three on the identity of zero (20,21 and 22); one illustrated the distributive law (24); and one illustrated the subtracting of fractions (25).

None of the test questions was worded in such a way as to make it unfair to those children studying traditional mathematics. In other words, such labels as commutative law, identity number, and other modern vocabulary were not mentioned; but the principles were tested. The test and questionnaire which accompanied it were mimeographed on three different colors of paper. Each administration of the test involved the use of a different color in an attempt to convince the children that they were taking a new test.

II. CONSTRUCTING THE QUESTIONNAIRE

In constructing the questionnaire, it was hoped to get answers to these questions: (1) Does the method of teaching mathematics influence children's interest in it and appreciation of it? (2) Does the amount of time spent on the study of mathematics have an effect on or influence the child's attitude? (3) Does the interest of the family have an effect on or relation to the child's attitude? (4) Does the amount of mathematical background of the parents have an effect on or relation to the child's attitude towards mathematics?

In the first part of the questionnaire the children were asked to rank the basic subjects studied according to their interest. Space was left for additional subjects if they cared to list them. In the second part of the Interest--Attitude Inventory, questions were asked to elicit other facts pertinent to the study. A copy of the questionnaire may be seen in the Appendix.

III. INITIATING THE EXPERIMENT

At the workshop conducted at the beginning of the school year in the Grand Rapids School District, the teachers who were to take part in the experiment were asked to attend a special meeting. Here the plan of the experiment was explained to them, and they were assigned the method they were to teach for the ensuing year. A time allotment of 40 minutes a day or 200 minutes a week was to be used by all teachers in the experiment. This conformed with the district recommendations of time distribution.

Books for the modern mathematics groups were purchased and already in the schools which were to participate in this part of the program. The traditional group would use the same basic text in use throughout the school district.

IV. NECESSITY OF A CHANGE

At the half-year, the plan for the experiment had to be changed since the school district had purchased new modern mathematics texts for all grades, and the superintendent asked that all pupils be taught modern mathematics from that time forward. Instead of concluding the experiment at this juncture, it was decided to continue it for the balance of the school year. A comparison could then be made as to how children taught modern mathematics for half a year would compare with those taught by this method for a whole school year.

V. SUMMARY

In this chapter, a description of the experiment's initiation was presented. A description of the Test in Understandings and the questionnaire was included with their proposed use. The necessity of a change of plan was explained.

In the next chapter, the results of the testing program will be shown and an evaluation will be made of the results obtained. Data obtained from the questionnaire will also be presented.

CHAPTER V

RESULTS AND EVALUATIONS

The Iowa Tests of Basic Skills in arithmetic fundamentals and problem solving were administered by the individual teacher to his own class in January and May, 1965. These tests were scored by the experimenter and compared with the ones given at the beginning of the school year to see if growth differences were significant.

The Test in Understandings was administered by the elementary co-ordinator to each of the six classes. These also were corrected by the experimenter and compared to the original tests to see if growth differences were significant when the control group was compared to the experimental group.

The Interest-Attitude Inventory was administered at the same time as the Test in Understandings and evaluated by the experimenter.

I. RESULTS OF IOWA BASIC SKILLS TESTS

A comparison of the control group and experimental group in Arithmetic Concepts A-I at the beginning of the year, (refer to page 37, Table VIII), shows them to be very similar with only a .04 difference in means. A comparison of the two groups at the middle of the school year (January, 1965) again shows a mean difference of only .04. This is not statistically significant (t-value = .25).

TABLE XII

MID-YEAR COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF ARITHMETIC CONCEPTS (IOWA TEST OF BASIC SKILLS), JANUARY, 1965

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	6.83	.84		D	22	6.95	1.09	
B	29	7.61	1.10		E	23	7.59	1.09	
C	24	7.97	1.08		F	33	7.53	.70	
Comp.	83	7.43	1.11	.12	Comp.	78	7.39	.98	.11

Comparison of Composite Means
Difference in the Means = .04
SE of difference....... = .16
t...................... = .25

It is evident that both groups compare favorably in the learning of arithmetic concepts at the midyear. For comparison of growth see Table VIII, page 37, where it may be seen that both groups advanced an average of .65 points with respect to the mean score. However, in examining the mean scores of the individual classes, Class A in the experimental group advanced only .23 in mean score; whereas Class C advanced 2.12 in mean score. This might be partially accounted for because of the difference in the means in intelligence quotients. On the Lorge-Thorndike Intelligence Tests, Non-Verbal Battery, Class A has a mean IQ of 101.50, and Class C has a mean IQ of 107.21. In the control group, Class E made the most gain in means (.82) and if one refers to the Lorge-Thorndike Intelligence Test Table III, page 32, it may be seen that this group also has the highest IQ on the Non Verbal battery in the control group. The least gain in means in the control group was made by Group D (.42). This group also has a relatively low IQ mean of 100.04.

TABLE XIII

MID-YEAR COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS
ON THE BASIS OF PROBLEM SOLVING
(IOWA TEST OF BASIC SKILLS), JANUARY, 1965

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	6.83	1.02		D	22	6.93	1.16	
B	29	7.34	1.41		E	23	7.00	1.07	
C	24	7.62	1.37		F	33	7.34	.93	
Comp.	83	7.24	1.31	.14	Comp.	78	7.12	1.06	.12

Comparison of Composite Means
Difference in the Means =.12
SE of difference....... =.18
t...................... =.67

As the above table shows, both groups compared favorably with regard to midterm achievement in problem solving. The t-ratio of .67 indicates that there is no statistical difference at the five percent level. In comparing this table with the initial test in problem solving Table IX, page 38, it is apparent that each class gained some ability to solve problems, but not to the extent that they gained in increased computational ability. It is interesting to note that Class C in the experimental group leads this group again with a mean gain of .67 as compared to the computational mean gain of 2.12. Class A again is lowest in this group with a mean gain of .16. In the control group Class D, which made the lowest mean gain in computation, leads the group with a mean gain of .64; while Class E, which made the most mean gain in computation, made the least mean gain in problem solving (.28). It is possible that some teachers stressed problem solving and others stressed computation during this half year. A comparison the two groups at the middle of the year (January, 1965) indicates that the control group was very slightly superior to the experimental group in mean performance. The difference in growth of .38 for the experimental group as compared to .47 for the control group is not significant, of course, and the experimental group still has .12 mean advantage.

The Arithmetic Concepts test administered in May, 1965, continued to show the same difference between the means of the two groups (.04) points which had been found on the same test administered during the previous two testing periods. The t-ratio shows that this is not significant at the five per cent level. Both classes show a composite mean score growth of .40 which does not show as much growth as the mean score growth of .65 on the first half year.

TABLE XIV

FINAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF ARITHMETIC CONCEPTS (IOWA TEST OF BASIC SKILLS), MAY, 1965

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	29	7.66	.78		D	22	7.22	.98	
B	28	8.13	.92		E	23	8.18	1.05	
C	24	8.01	1.19		F	32	7.93	.75	
Comp.	81	7.83	1.03	.12	Comp.	77	7.79	1.01	.12

Comparison of Composite Means
Difference in the Means = .04
SE of difference....... = .17
t..................... = .24

A study of the gains made by individual classes during the periods, September, 1964 to January, 1965, and January, 1965 to May, 1965, reveals some interesting contrasts. It was shown earlier that Class C of the experimental group gained 2.12 points on the Iowa Test (Arithmetic Concepts, A-I) during the first of these periods (see page 51), but it gained only .04 points during the second period of time. The gains of Class A, on the other hand, during these two instructional periods were .23 and 83. points respectively.

With regard to the control group, Class D, which made the smallest mean gain from September 1964 to January 1965 (.42), also made the smallest mean gain during the second half year of the experiment (.27). Class E, on the other hand, made the highest mean gain during both phases of the experiment (.82 and .59), respectively.

TABLE XV

FINAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF PROBLEM SOLVING (IOWA TEST OF BASIC SKILLS), MAY, 1965

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE$_{X1}$	CLASS	N	$\bar{X}$	SD	SE$_{X2}$
A	29	7.30	.97		D	22	7.27	1.07	
B	28	7.95	1.41		E	23	7.76	1.26	
C	24	8.14	1.49		F	32	7.73	.95	
Comp.	81	7.77	1.35	.15	Comp.	77	7.61	1.10	.13

Comparison of Composite Means
Difference in the Means = .16
SE of difference....... = .20
<u>t</u>...................... = .80

It is evident by examining the above table that both groups compare favorably with regard to end-of-year achievement in problem solving. A comparison of the two groups at the end of the year (May, 1965) indicates that the experimental group was slightly superior to the control group in mean performance. However, the mean difference of only .16 is not significant, and is assumed to be due to chance factors. All of the classes in the experimental group made approximately the same mean growth during the second half year (Class A - .47, Class B - .61 and Class C - .52). The composite mean growth was .53 as compared to the January test which showed a mean growth of only .38.

In comparing data from Table XIII and XV, additional contrasts are noted with respect to gains in problem solving, with respect to individual classes. From January to May, Group D made the smallest mean growth (.34) as compared to the largest one from September to January (.64); while Group E made the largest mean growth from January to May (.70) as compared to the smallest one from September to January (.28). Group D also made the smallest computational mean growth from January to May (.27) and from January to May (.42). However, Group E, which made the highest mean growth in problem solving (.76), also made the highest mean growth in computation (.59) from January to May.

In computation mean growth for the year, both groups show a mean growth of 1.05. In problem solving, the experimental group made a mean growth of .91 and the control group made a mean growth of .96. If 1.00 is considered to be a normal year's mean growth, then in computation both groups achieved slightly over the average, and in problem solving both groups achieved slightly under the average expectancy of growth.

In comparing mean growth to IQ tests obtained on the verbal battery, it would appear that groups with a relatively high IQ would do better in both arithmetic concepts and problem solving than those with a lower mean IQ. In the experimental group Class C with a mean IQ of 107.21 showed a mean growth of 1.16 in arithmetic concepts and 1.19 in arithmetic problem solving. In the control group the highest mean IQ was found in Class E, (105.75), which had a mean growth of 1.41 in arithmetic concepts and 1.04 in arithmetic problem solving. The results in the comparison of the other classes are:

1. Class B with an average IQ of 104.33 showed a mean growth of 1.23 years in arithmetic concepts and a mean growth of .97 in problem solving.
2. Class F with an average IQ of 103.81 showed a mean growth of 1.08 years in arithmetic concepts and a mean growth of .90 years in problem solving.
3. Class A with an average IQ of 101.50 showed a mean growth of 1.06 years in arithmetic concepts and a mean growth of .63 years in problem solving.
4. Class D with an average IQ of 100.04 showed a mean growth of .69 years in arithmetic concepts and a mean growth of .98 years in problem solving.

In all classes except Class D the children with relatively lower IQs did better in arithmetic concepts than in problem solving.

II. RESULTS OF TEST IN UNDERSTANDING

It was shown earlier (Table XI, page 40) that with regard to the initial status in the <u>Test in Understanding</u>, the experimental group was somewhat superior to the control group in mean performance. The difference of .78 points in favor of the experimental composite group means, however, was found to be not significant at the five per cent level as the t-value obtained was .64.

TABLE XVI

MID-YEAR COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF TEST IN UNDERSTANDINGS JANUARY, 1965

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	30	35.67	8.55		D	21	33.19	9.75	
B	29	41.83	11.15		E	23	36.35	9.90	
C	24	42.00	11.55		F	33	38.21	7.40	
Comp.	83	39.65	10.85	1.20	Comp.	77	36.52	9.10	1.04

Comparison of Composite Means
Difference in the Means = 3.13
SE of difference........ = 1.59
<u>t</u>...................... = 1.97

Table XVI shows a comparison of the test scores in understandings for the two groups in January, 1965. The experimental group had a 3.13 higher point mean than the control group. When the t-value was found, this proved to be significant at the five per cent level. Such a gain then would not be considered to be due to chance, but could be assumed in this case to be due to the content and method of teaching used in the experiment.

In the experimental group, Class B (Verbal IQ means-112.50 and Non-Verbal mean IQ-104.33) made the largest mean growth of 11.33. (Refer to Tables XI and XVI). Class C also made a large mean growth in understandings (8.33). The mean Verbal IQ of this class was 108.05, while its mean Non-Verbal IQ was 104.14. Class A, which showed a much less mean growth in understandings (5.34), had a mean Verbal IQ of 106.35, and a mean Non-Verbal IQ of 101.50. Perhaps this difference in IQ means affected the growth in understandings.

In the control group Class E, with a mean Verbal IQ of 110.35 and a mean Non-Verbal IQ of 105.75, made the greatest mean growth in understandings (7.39). Class D and F made a mean growth in understandings of 5.10 and 4.70 respectively. However, Class D had a mean Verbal IQ of 104.83 and a mean Non-Verbal IQ of 100.04, which was quite a bit lower than the mean IQs of Class F (Verbal-110.65 and Non-Verbal-103.81). This does not seem to warrant the assumption made previously--that a high IQ might affect mean growth in understandings.

Since the experimental and control groups were not identical at the beginning of the experiment on the basis of mean performance in the Test of Understandings, it was decided to carry out another comparison, this with respect to individual gains made from the beginning of the experiment to January.

Table XVII indicates that the children in the experimental classes gained 2.52 points more, on the average, than did the children in the control classes. This difference is significant at the five per cent level (t = 2.45).

The above findings tend to support the assumption made previously that modern content and approaches to the teaching of mathematics lead to a better understanding of the number system than can be expected through traditional content and methods.

TABLE XVII

MID-YEAR COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS' INDIVIDUAL GAINS ON THE BASIS OF TEST IN UNDERSTANDINGS, JANUARY, 1965

GROUP	NUMBER	MEANS GAIN	SD
EXPERIMENTAL	83	7.71	6.72
CONTROL	78	5.19	6.24

Difference in the Means - 2.52
SE of difference....... - 1.03
t..................... - 2.45

TABLE XVIII

FINAL COMPARISON OF EXPERIMENTAL AND CONTROL GROUPS ON THE BASIS OF TEST IN UNDERSTANDINGS
MAY, 1965

EXPERIMENTAL					CONTROL				
CLASS	N	$\bar{X}$	SD	SE_{X1}	CLASS	N	$\bar{X}$	SD	SE_{X2}
A	28	39.50	9.20		D	22	36.09	10.70	
B	28	48.61	10.95		E	23	45.05	12.50	
C	24	43.87	13.55		F	33	45.79	8.25	
Comp.	80	44.00	11.85	1.30	Comp.	78	42.83	11.20	1.27

Comparison of Composite Means
Difference in the Means = 1.17
SE of difference....... = 1.82
t...................... = .64

Table XVIII, which shows the comparison of the two groups in May, indicates that the modern group still was somewhat superior to the traditional group in mean performance. However, the difference in mean performance of 1.17 of the composite classes was found to be statistically not significant when the t-ratio was applied. At this time the control group had received a half year of modern mathematics instruction, and the experimental group had received a whole year of this type of instruction.

The control group had a mean growth of 6.31 from January to May as compared to the experimental mean growth of the composite of 4.35 in the same period (Table XVI, page 58 and Table XVIII, page 61). The control group had had a composite mean growth of 5.95 in January as compared to the experimental group of 8.30 (Table XI, page 40 and Table XVI, page 58). The control group seemed to move rather steadily ahead while the experimental group showed a rapid growth and then a slowing down. The experimental group showed a mean growth for the school year of 12.65 in understandings. The control group showed a composite mean growth of 12.26 for the school year. (Table XI, page 40 and Table XVIII, page 61)

In analyzing the classes individually it is interesting to note that Class B which showed the greatest mean growth in January (11.33), refer to Table XVI, also showed the greatest mean growth in May (6.78). As has been pointed out, this class has a high mean IQ, but not a great deal higher than Class C. Teacher interest and enthusiasm may have contributed to this difference. The total mean growth for the Class in understandings (18.11) is 5.46 points higher than the mean growth for the composite experimental class.

Class C, which had achieved a mean growth of 8.33 points by January, showed only an additional growth of 1.87 points in means by May, whereas Class A, with a mean growth of 5.34 by January, continued to grow more evenly, with an additional mean growth of 3.83 points by May. A question arises in the examiner's mind as to what happened in Class C's environment to cause this slowing down in rate of growth. The IQ means for Class C, as may be seen by referring to Table II and III, pages 31-32, is comparatively high.

Class E, which had the highest mean growth by January (7.39 points), also had the highest additional mean growth by May (8.69 points). The total mean growth for the year (16.08) is well above the composite mean growth for the control group (12.26). Class D, with a mean growth of 5.10 by January and 2.90 by May, showed the only decrease in mean growth when modern mathematics was introduced. Class F, with a mean growth of 4.70 by January, improved more rapidly under the teaching of modern mathematics, with a mean growth of 7.58 by May; a total of 13.53 for the year.

The results of this testing program support the hypothesis that there would be no significant difference in the ability of children to compute accurately between pupils taught in a modern mathematics program as compared to those taught by the traditional type of program. No significant difference was found between the control and experimental groups with respect to their ability to solve problems. However, a significant difference at the five per cent level was found at the mid-year in the ability of children to understand the number system and its function. The experimental group were superior in this test. After the control group had been taught modern mathematics for half a year no significant differences were found in the test for understandings. However, the experimental group which had received modern mathematics training for a whole year still were slightly superior.

III. EVALUATION OF THE QUESTIONNAIRE

In order to determine the students' interests and their attitudes toward mathematics, a questionnaire was presented to them three times during the year. Each student ranked his interest from one through eight in six listed subjects and two blanks upon which they could indicate other choices if they desired to do so. The first choice was weighted six; the second, five; and similar weights were assigned down to a weight of one for the sixth choice. Zero was assigned to each subject in which a child expressed no interest. The seventh and eighth choices were discarded, as many of them did not fill in the two optional blanks. The weighted interest in each subject was totaled for the experimental classes and for the control classes, and each of these numbers was divided by the number of questionnaires filled in each section. This final number for each subject, listed in the chart below, represents the comparative interest between that subject and the total interest possible. A score of six would mean that every child put that subject first in ranking order. The results for August, January, and May are shown.

In August, the experimental group chose mathematics as their favorite subject with a weighted value of 3.78. This was followed by reading (3.46, science (3.29), and spelling (3.14). In January, mathematics was still their favorite subject although it had decreased a little in popularity. Reading was their second choice and this was followed by science and spelling. In May mathematics continued as first choice, but again had decreased slightly in popularity. Science had gained in popularity and ranked second in pupils' choice of favorite subject. Spelling ranked third at this time, and reading was fourth.

Mathematics, when taught by modern methods, does not seem to engender more interest than it had before the study. However, mathematics appears to be liked by children for its own sake.

TABLE XIX

COMPARATIVE PUPIL INTEREST IN THE
VARIOUS CURRICULUM AREAS AT DIFFERENT INTERVALS OF TIME
(HIGHER VALUES INDICATE HIGHER PREFERENCES)

	EXPERIMENTAL COMPOSITE			CONTROL COMPOSITE		
	AUGUST	JANUARY	MAY	AUGUST	JANUARY	MAY
SUBJECT						
English	2.55	2.78	2.65	2.66	2.55	2.88
Soc. St.	2.61	2.55	2.41	3.06	2.83	2.69
Math.	3.78	3.73	3.69	4.05	4.17	3.55
Science	3.29	3.07	3.44	2.85	3.10	3.23
Reading	3.46	3.44	3.04	3.23	2.72	2.97
Spelling	3.14	3.02	3.18	3.20	3.31	3.18
Art	1.09	1.45	1.22	1.03	.65	1.31
Music	.44	.10	.57	.49	.86	.74
Phy. Ed.	.52	.65	.61	.39	.62	.34
Others	.10	.20	.19	.13	.19	.11

The control group, in August, ranked mathematics as first choice with a greater weighted value (4.05) than the experimental group (3.78). Reading ranked in second place (3.23), while spelling (3.20), and social studies (3.06) held third and fourth places in children's interest.

In January, the control group again ranked mathematics as best-liked subject, with a slight increase in the comparative value (4.05-4.17). Spelling (3.31), science (3.10), and social studies (2.83) ranked second through fourth choices respectively. At this time they had studied traditional mathematics as they had in other grades.

In May, when the control group had studied modern mathematics for half a year, mathematics still ranked first in popularity; but the interest in it was less than it had been in the previous inventories (3.55). It also had a lower rank order than the experimental group in May (3.55-3.69). This drop in popularity may have been due to the fact that the subject was introduced in the middle of the school year; and the teachers may have felt a need to try to cover all the material, and so hurried the children in their classes a little more than they should have. Science (3.23), spelling (3.18), reading (2.97), and English (2.88) ranked second to fifth places respectively. Science is the only subject which seemed to have gained each time in popularity.

The fact that mathematics was the first choice of subjects in both groups seems to support the hypothesis of educators that children do like mathematics and will enjoy it for its own sake.

Table XX shows the answers to the questionnaire which was filled out three times during the year. In the Table the questions are stated, and the answers given by the two groups are given in percentage form. Following the Table a short discussion is given.

TABLE XX

ANSWERS TO QUESTIONS IN INTEREST-ATTITUDE INVENTORY AT DIFFERENT INTERVALS OF TIME

1. Which subject have you spent the most time on outside of class in the past?

	EXPERIMENTAL GROUP			CONTROL GROUP		
Subject	August	January	May	August	January	May
English	4%	5%	3%	2%	1%	6%
Social Studies	6	21	11	16	18	60
Mathematics	42	39	47	39	59	13
Science	8	4	5	10	9	15
Reading	21	25	23	25	8	3
Spelling	4	4	4	5	4	3
Art	6	2	4	-	-	-
Music	1	-	3	1	1	-
Physical Edu.	4	-	-	2	-	-
Recreation	4	-	-	-	-	-

2. Which subject now receives the most of your time?

	EXPERIMENTAL GROUP			CONTROL GROUP		
Subject	August	January	May	August	January	May
English	5%	2%	1%	2.5%	3%	5.0%
Social Studies	20	12	10	29.0	17	16.0
Mathematics	35	55	59	31.0	57	62.0
Science	4	6	5	5.0	11	5.0
Reading	20	15	15	17.0	4	5.0
Spelling	10	4	4	11.0	4	5.0
Art	5	4	4	-	1	4.0
Music	-	1	2	2.5	3	1.5
Others	1	1	-	2.0	-	1.5

3. Indicate your interest in mathematics as follows: (high, average, low).

	EXPERIMENTAL GROUP			CONTROL GROUP		
	August	January	May	August	January	May
High	25%	33%	30%	17%	42%	29%
Average	71	52	64	77	54	59
Low	4	15	6	6	4	12

TABLE XX (continued)

4. How much help do you get from your parents or other members of the family in the study of mathematics? Choose one of the following: (a) help every day, (b) help quite often, (c) some help, (d) no help.

Degree of Help	EXPERIMENTAL GROUP			CONTROL GROUP		
	August	January	May	August	January	May
a	4%	-%	-%	13%	3%	5%
b	12	14	13	17	26	13
c	69	67	71	66	59	65
d	15	19	16	4	12	17

5. To do my homework in mathematics-select one of the following: (a) parents get after me every day, (b) parents get after me quite often, (c) parents get after me occasionally, (d) on my own.

Degree of Help	EXPERIMENTAL GROUP			CONTROL GROUP		
	August	January	May	August	January	May
a	5%	-%	1%	13%	4%	6%
b	2	5	5	22	6	13
c	35	38	39	42	32	23
d	58	57	55	23	58	58

6. How much mathematics has your father had? Select one of the following: (a) junior high only, (b) algebra and plane geometry, (c) complete high school mathematics program, (d) at least one college mathematics course, (e) don't know.

Years of Math study	EXPERIMENTAL GROUP			CONTROL GROUP		
	August	January	May	August	January	May
a	6%	6%	6%	12%	6%	16%
b	1	4	3	2	-	-
c	12	19	6	14	14	16
d	5	2	9	9	43	8
e	76	69	76	63	37	60

TABLE XX (continued)

7. How much mathematics has your mother had? (Use one of the choices in question 6).

	EXPERIMENTAL GROUP			CONTROL GROUP		
Years of Math study	August	January	May	August	January	May
a	7%	7%	6%	16%	6%	10%
b	1	-	1	1	3	-
c	13	22	17	10	18	19
d	4	5	5	7	17	13
e	75	66	71	66	56	58

8. Is mathematics discussed in your home? Select one of the following: (a) always, (b) quite often, (c) sometimes, (d) never.

	EXPERIMENTAL GROUP			CONTROL GROUP		
Amount of discussion	August	January	May	August	January	May
a	5%	1%	-%	3%	5%	2%
b	20	25	21	25	23	22
c	68	65	74	66	66	68
d	7	9	5	6	6	8

In examining Table XX which shows the results obtained by the questionnaire, one notices that the control group felt that they spent an increasing amount of their time outside of class studying mathematics. This was especially true while they were studying traditional mathematics, where there was a 20 per cent increase in time. After they began studying modern mathematics, the amount of time increased by only one per cent. The time spent on reading decreased by 17 per cent in the first half year, but increased seven per cent in the second half. In social studies there was a decrease of time spent during the second half of the year of 12 per cent.

The experimental group spent 15 per cent more of their time on social studies during the first half of the year. However, this decreased by 10 per cent during the last half of the year. The study of mathematics increased eight per cent, also, during the second half of the year. Both groups spent more time studying mathematics than any other subject.

In studying pupil responses to question two, one is again impressed with the seemingly disproportionate amount of time spent studying their mathematics assignments as compared with all their other school subjects. At the beginning of the year the average amount of time spent by the control group was almost one third of their study time. This figure then increased to over half of their study time. The same round figures hold true for the experimental group, also.

Social studies and reading claimed most of the balance of their time at the start of the school year. In both groups the time spent on these two subjects decreased with the year's work.

The following questions might arise in one's mind: "Is this a true picture or did the child only feel it to be true? If it is true, does the child need this much time spent on one subject, or is it that it is easier to get help at home in this area and so he completes his other assignments at school and takes his mathematics home?" More research would have to be done to provide an answer to these questions.

The answer to question three is pertinent to our attempt to find an answer to hypothesis number four; there will be no difference in pupil interest in and enjoyment of mathematics whether they are taught by modern methods or traditional methods of mathematics. Among the children in the control group, interest was high in 17 per cent of the sample at the start of the school year. After a half year of instruction in traditional mathematics, high interest was expressed by 42 per cent of the children. This was an increase of 25 per cent. After studying modern mathematics for half a year, this high interest decreased 13 per cent. The children with low interest in mathematics in the control group showed little change while they were studying traditional mathematics, but eight per cent more of them claimed to feel low interest after they had studied modern mathematics for half a year.

In the experimental group there was little change in interest shown in mathematics. There was an eight per cent increase in January among those expressing high interest. There was also an 11 per cent increase in those professing to have low interest in mathematics. By May, both of these figures had decreased again. From this study it would seem that children are more interested in traditional mathematics courses.

In answering question number four, most of the children in both groups felt that they got some help at home in studying their mathematics assignments. In the experimental group four per cent of the children felt that they received help every day at the start of the school year. In January and May none of the children in this group claimed to get help every day. About one-sixth of this group also reported that they received no help. This could be caused by the parents' unfamiliarity with modern mathematics.

In answering question number five, more of the control group report that their parents get after them every day, or that their parents get after them very often than do the parents of the experimental group. Both groups report that their parents get after them occasionally. However, the concern of parents of the control group decreased as time went on, while that of the parents of the experimental group remained about the same. A little more than half the experimental group claim to be on their own with regard to responsibility for homework throughout the course of the study. Only 23 per cent of the control group claimed to be on their own at the beginning of the experiment, but by the half year this had increased to 58 per cent. It is possible that as the children grew in ability they did not need as much help and so did not ask for it.

On questions six and seven, many pupils answered "I don't know". Because of the incompleteness of these returns, with the resulting lack of validity, these questions are not being discussed in this paper. A questionnaire sent home to the parents at the start of the experiment would have presented a more valid answer.

About one-fourth of the children in both groups claim that mathematics is discussed in their home quite often (20%-25%). Sixty-six per cent of the children in the control group claim that it is discussed sometimes. This figure raised two per cent when they began taking modern mathematics. In the experimental group, the number who discussed it sometimes increased from 68 per cent to 74 per cent. This would bear out the belief of mathematicians and other scientists that American people are becoming more aware of mathematics and its problems. Many of them undoubtedly find a greater need for mathematics in their daily work and reading, also.

IV. SUMMARY

In Chapter V the results of the Iowa Basic Skills Test were presented, and comparisons were drawn between these and also with the ones given at the beginning of the year. In the next section the results of the Test in Understandings were presented. These were compared with each other and with the initial test. No significant differences were found in any of the tests except in the test in understandings which was administered in January. This showed a superior result on the part of the experimental group which was significant at the five per cent level.

The questionnaire then was evaluated. It was shown that pupils tend to rank mathematics high as a favorite subject in both groups. They also report spending a great deal of outside study in the subject. A larger percentage of the children in the traditional classes expressed high interest in mathematics than did those in the experimental classes. Apparently mathematics is being discussed a great deal in the homes of these children, and by inference in the United States, according to their answers on the questionnaire.

In Chapter VI, the final chapter, a summary of the experiment will be given and some conclusions will be drawn in relation to the hypotheses given at the beginning of this paper.

CHAPTER VI

SUMMARY AND CONCLUSIONS

I. SUMMARY

This study was set up to determine the nature and extent of learning of computational skills and problem solving techniques when presented in a modern mathematics program. By a comparison of sixth grade classes divided into equivalent groups and taught by two different methods--traditional and modern--a partial answer was derived. The *Iowa Test of Basic Skills* was used to measure achievement in computation and problem solving skills. Two further questions were explored at the same time (1) which method better developed understandings of the concepts of mathematics, and (2) which method engendered more enjoyment and enthusiasm on the part of the student? A test in understandings and a questionnaire constructed by the experimenter were used to obtain data for the purpose of attempting to answer these two questions.

Other studies pertaining to this problem do not provide substantial evidence to favor either method as the better one to use in the teaching of mathematics. This is due to the fact that much of the new mathematics is still experimental and studies have not been published or have been sharply criticised as not being carefully enough controlled.

Three classes in each group made up of sixth grade pupils in the Grand Rapids, Minnesota, school system during the school year 1964-65 composed the samples to be tested. The groups were equated on the basis of IQ (Lorge-Thorndike Intelligence Test, Verbal and Non-Verbal), chronological ages, achievement in all school subjects (Iowa Test of Basic Skills), and mathematical understandings (Test in Understandings). The two groups then were taught by two different methods of instruction in mathematics for the first half year, the modern (experimental group) and the traditional (control group). At the half year point, the design of the experiment was modified, with the result that both groups were taught mathematics from the modern approach.

The pupils in the experimental and control groups learned approximately an equal amount of computational skills and problem solving abilities at the end of the half year with a very slight but statistically insignificant superiority shown by the control group in problem solving. In understandings the experimental group showed significant superiority over the control group. The control group at this time evinced more interest in mathematics with 42 per cent showing high interest compared to 33 per cent of the experimental group; and only four per cent professing low interest compared to 15 per cent of the experimental group.

At the close of the school year both groups showed an approximately equal growth in computation and problem solving abilities. Both groups showed a mean growth of 1.05 in computation. In problem solving, the control group showed a mean growth of .96, and the experimental group showed a mean growth of .91. In understandings, the experimental group with a superior mean performance of 1.17 seemed to be somewhat superior to the control group, but this was found to be statistically not significant. There was no difference in interest displayed at this time by either group, but the control group which had had modern mathematics for only half a year showed a 13 per cent loss of high interest and an eight per cent gain in low interest in mathematics.

In both groups, mathematics ranked first as their favorite subject at all three testing periods. Both groups reported spending a disproportionate amount of time on mathematics outside of school time as compared to all other subjects. They also admitted that they received some help in mathematics at home. Apparently mathematics is being discussed in their homes quite frequently.

II. CONCLUSIONS

The study indicates that children taught modern mathematics as described in this paper did as well as those children taught in the traditional curriculum when compared with respect to basic computation and problem solving. It must be pointed out that the tests given were standardized for traditional mathematics. At the time of the experiment there were no tests covering these outcomes which were standardized for modern mathematics programs.

They also did as well in achievement in computation and problem solving as other classes when compared to the national norms for the test.

In the test for understandings, it was apparent that the experimental group did better work than did the control group at the half year. The control group bettered their previous record when taught modern mathematics during the second half of the year. The experimental group were still superior at this time but not significantly so. It would seem that modern mathematics teaches a better understanding of the number system and its functions than does the more traditional approach.

Another factor to be considered in evaluating this study is that neither the students involved nor the teachers had any prior background in modern mathematics. The in-service training for the teachers was being given at the same time they began teaching the course. The textbooks were unfamiliar to the teachers since they saw them for the first time on the day school opened. Considering this information, the results obtained show that modern mathematics has an equal if not higher value than traditional mathematics as a method of teaching our mathematics today.

The fact that traditional mathematics seems to evoke the greater interest may be due to the unfamiliarity of the teacher with the material, the lack of a modern mathematics background on the part of the children which would tend to make it more difficult for them to understand, and other factors such as poor teacher attitude towards the subject, poor family attitude toward the subject, or a lack of material with which to work.

III. IMPLICATIONS OF THE STUDY

Both traditional and modern instructional methods of teaching sixth grade mathematics are acceptable when measured by traditional standardized tests. However, modern mathematics seems to give children a better understanding of mathematical concepts. A study of this type would be more valid if it could have a longer duration. The children in the experimental group should have had a year or more of modern mathematics background, and the teachers should have been experienced modern mathematics teachers. Standardized tests to test modern mathematics concepts also will have to be devised.

As studies are still going on and new textbooks being written, the final word has not been said, as yet, about mathematics. Many methods now proposed must be tried out, and teachers must take an active part in the study. Certainly, educators must be constantly evaluating the new and the old programs in order to keep the good of both of them and discard the bad or outdated parts of the mathematics program.

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APPENDIX

SCHOOL DISTRICT NUMBER 318
ITASCA COUNTY
GRAND RAPIDS, MINNESOTA

INTEREST-ATTITUDE INVENTORY

DATE ____________________ SCHOOL ____________________ NAME ____________________

This questionnaire is designed to determine the attitudes and interests of students in the field of mathematics and other areas. Read each question or statement thoroughly before answering. Select the answer for each statement or question that you feel best fits your situation. Please answer as truthfully as possible. All the information you give will be kept confidential (secret) and will not influence your marks in any way.

Please rank the following courses according to your interest by writing the numeral 1 for the course that you find the most interesting, 2 for the second most interesting course, and so on. Be sure to number each course that is listed. You may add other courses if you wish to do so and rank them also.

a. English ______

b. Social Studies ______

c. Mathematics ______

d. Science ______

e. Reading ______

f. Spelling ______

g. ______

h. ______

______________________ 1. Which subject have you spent the most time on outside of class in the past?

______________________ 2. Which subject now receives the most of your time?

______________________ 3. Indicate your interest in mathematics as follows: (high, average, low).

______________________ 4. How much help do you get from your parents or other members of the family in the study of mathematics? Choose one of the following: (a) help every day (b) help quite often (c) some help (d) no help.

______________________ 5. To do my homework in mathematics - select one of the following: (a) parents get after me every day (b) parents get after me quite often (c) parents get after me occasionally (d) on my own.

______________________ 6. How much mathematics has your father had? Select one of the following: (a) junior high only (b) algebr and plane geometry (c) complete high school math program (d) at least one college mathematics course (e) don't know.

______________________ 7. How much mathematics has your mother had? (Use one of the choices in question 6)

______________________ 8. Is mathematics discussed in your home? Select one of the following: (a) always (b) quite often (c) sometimes (d) never.

SCHOOL DISTRICT NUMBER 318
ITASCA COUNTY
GRAND RAPIDS, MINNESOTA

TEST OF UNDERSTANDINGS IN MATHEMATICS - GRADE VI

SCHOOL ______________________ NAME ______________________

DATE ______________ SCORE ______________

DIRECTIONS: In each of the examples below there are four possible answers. Choose the correct answer and place its letter in the blank provided to the left of the numeral. Do any computation necessary in the space provided to the right of the problem.

EXAMPLE:

C 1. When we add 2 and 4 the sum is
- A. 8
- B. 2
- C. 6
- D. None of these

____ 1. It takes how many figures to write one million?
- A. 7
- B. 9
- C. 11
- D. None of these

____ 2. Which means 27 hundreds and 3 tens?
- A. 27,030
- B. 2703
- C. 2730
- D. None of these

____ 3. 98,690 rounded to the nearest thousand is
- A. 90,000
- B. 98,000
- C. 99,000
- D. 100,000

____ 4. Which is read fourteen million, three thousand, thirty-four?
- A. 14,003,340
- B. 14,300,034
- C. 14,003,034
- D. None of these

____ 5. How many groups of 100 objects equal 6,000 objects
- A. 6
- B. 60
- C. 6,000
- D. None of these

____ 6. The average of $4\frac{1}{2}$, $3\frac{1}{4}$, and 2 3/8 is
- A. 3 3/8
- B. 9 5/8
- C. 9 9/8
- D. 10 1/8

_____ 7. 15,340,000 equals how many ten thousands?
A. 5
B. 15,340
C. 340
D. 1,534

_____ 8. How many thousands does it take to make a million?
A. 10 hundred
B. 1 hundred
C. 10 thousand
D. 1 thousand

_____ 9. A rectangle 24 inches by 36 inches contains how many square feet?
A. 5
B. 6
C. 60
D. 864

_____10. 10 X 10 X 10 X 10 equals
A. 10,000
B. 100,000
C. 1,000
D. None of these

_____11. Using Roman numerals to count by ones, the next number after CLXXXIX would be written
A. CXC
B. CLIV
C. CLXXXX
D. CLXXXIXI

_____12. Which is the Roman numeral for 346?
A. CCXLIX
B. CCCXLVI
C. CCXLVI
D. None of these

_____13. 6 3/4 X 3 1/4 =
A. 18½
B. 21 15/16
C. 23 5/8
D. 25 3/4

_____14. Which of the following numerals has the largest digit in the hundred thousands place?
A. 67,526,289
B. 9,879
C. 654,287
D. 100,000

_____15. Which numeral stands for a number that is 100 times 400?
A. 4,000
B. 400,000
C. 4,000,000
D. 40,000

_____16. 45/100 equals
A. 45
B. 4.5
C. .45
D. .045

_____17. The 6 with an x on top of it is how many times as large in value as the underlined 6?

$$\overset{x}{6}6{,}6\underline{6}6$$

A. 600
B. 1000
C. 10,000
D. 100

_____18. Which numeral shows another way to write this?

thousands	hundreds	tens	ones
(3	34	19	8)

A. 4498
B. 6598
C. 6398
D. None of these

_____19. 7.5 X 4.3 =
A. 3225
B. 322.5
C. 32.25
D. 3.225

_____20. Which is read thirty thousand, three hundred three?
A. 3,303
B. 30,303
C. 30,033
D. None of these

_____21. 5,277 rounded to the nearest ten is
A. 528
B. 5,290
C. 5,300
D. 5,280

_____22. What per cent of 20 is 12?
A. 166 2/3%
B. 40%
C. 60%
D. None of these

_____23. How many groups of ten objects equal 34,280 objects?
A. 8
B. 428
C. 342
D. 3,428

_____24. 100 hundreds 40 tens mean the same as
A. 10,400
B. 10,040
C. 10,140
D. 14,000

_____25. 40% of 80 is
A. 3,200
B. 320
C. 32
D. None of these

_____26. Another name for 10,800 is which of these?
A. 10 + 800
B. 10,000 + 800
C. 1000 + 800
D. 108 + 100

_____27. A meaning for 300,000 is which of these?
A. 3000 hundreds
B. 30 thousands
C. 3000 tens
D. None of these

_____28. 5/12 expressed as a decimal correct to the nearest thousandth is
A. .500
B. .417
C. .416
D. None of these

_____29. By how much must you multiply a million to make a billion?
A. By 10,000
B. By 100
C. By 1,000
D. By 10

_____30. A meaning for 16,480 is which of these?
A. 16,480 tens
B. 1,648 tens
C. 16 hundreds, 480 tens
D. 1,648 tens 80 ones

_____31. 7,866,248 rounded to the nearest half million is

A. 8,000,000
B. 7,800,000
C. 7,500,000
D. 7,566,248

_____32. Look at the examples in the box. Annexing two zeroes to the right of 348 multiplies its value by how many times?

(348) (34,800)

A. 10
B. 1,000
C. 100
D. None of these

_____33. The 6 with an x on top is how many times as large in value as the underlined 6?

$\overset{x}{6}\underline{6},666$

A. 6
B. 10
C. 100
D. 1,000

_____34. Which of these numerals expresses the largest value?

A. .8
B. .756
C. .089
D. .7999

_____35. In 3412 the 4 represents a value how many times as large as the 2?

A. 2
B. 100
C. 200
D. 20

_____36. The mixed number 7 6/10,000 equals which of the following decimals?

A. 7.006
B. .76
C. 7.6
D. 7.0006

_____37. In which of these numerals does the 4 mean four million?

A. 47,350,000
B. 254,836,000
C. 74,862
D. 428,796

_____38. The perimeter of a square which measures 6 5/8 inches on a side is

A. 12 10/8 inches
B. 13¼ inches
C. 26½ inches
D. 36½ inches

_____39. The 3 with an x on top is how many times as large as the underlined 3?

$$\underline{3},\overset{x}{3}33$$

A. 10
B. 1/10
C. 1/100
D. 100

_____40. Which of the examples below will have the same answer as the example given here?

$$1.5\overline{)\,7.5}$$

A. $.15\overline{)\,7.5}$

B. $15\ \overline{)\,7.5}$

C. $15\ \overline{)\,75}$

D. $1.5\overline{)\ \ .75}$

_____41. Which of these fractions expresses the largest value?
A. 3/8
B. 1/4
C. 1/6
D. 1/2

_____42. The difference between the product of 37 and 93 and the product of 59 and 42 is
A. 963
B. 231
C. 29
D. None of these

_____43. Nine inches are what part of a yard?
A. ¼
B. 3/4
C. 9/12
D. None of these

_____44. Which of these fractions expresses the smallest value?
A. 1/12
B. 1/10
C. 1/8
D. 1/6

_____45. Which of these improper fractions can be changed to the whole number 3?
A. 9/4
B. 12/4
C. 15/9
D. None of these

TEST OF UNDERSTANDINGS IN MATHEMATICS - GRADE VI

TRUE OR FALSE

SCHOOL ____________________ NAME ____________________

DATE ____________________

DIRECTIONS: Read each statement carefully. Decide if it is true or false. Circle the T if the statement is true or the F if it is false.

T F 1. It takes 11 numerals to write a billion.

T F 2. 576,225 rounded to the nearest hundred thousand is 600,000.

T F 3. The Roman numeral for 879 is DCCCLXXIX.

T F 4. The Roman numeral for 784 is DCCLXXXVIX.

T F 5. The cornerstone of a building bears the date MCDL. This means that it was built in 1950.

T F 6. In a field 32 rods wide by 60 rods long there are 307,200 acres.

T F 7. 18 + 24 = 24 + 18

T F 8. 16 X 32 = 32 X 16

T F 9. 74 - 42 = 42 - 74

T F 10. 48 ÷ 6 = 6 ÷ 48

T F 11. (8 + 6) + 4 = 8 + (6 + 4)

T F 12. (10 - 6) - 4 = 10 - (6 - 4)

T F 13. (2 X 4) X 3 = 2 X (4 X 3)

T F 14. (48 ÷ 8) ÷ 2 = 48 ÷ (8 ÷ 2)

T F 15. In our numeration system we use only ten basic numerals.

T F 16. 4836 equals (4 X 10 X 10 X 10) + (8 X 10 X 10) + (3 X 10) + 6.

T F 17. 1456 equals 1000 + 400 + 50 + 6.

T F 18. $3\frac{1}{2}$, 3.5, 3.50, 7/2 all mean the same number.

T F 19. The sum of three whole numbers is 148.6.

T F 20. When we add zero to a number, the sum is that number.

T F 21. When we subtract zero from a number, we get the same number.

T F 22. When we multiply a number by zero, we get the same number.

T F 23. 3 3/8 is larger than 3 3/4.

T F 24. 6 X (3 + 4) = (6 X 3) + (6 X 4).

T F 25. 6 3/4 - 5 3/8 = 1 3/8