THE EFFECT OF SUPPLEMENTARY MATERIALS UPON ACADEMIC ACHIEVEMENT IN AND ATTITUDE TOWARD MATHEMATICS AMONG EIGHTH GRADE STUDENTS

DISSERTATION

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF EDUCATION

By

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Denton, Texas

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The problem of the study was to examine the effectiveness of using supplementary materials in the teaching of eighth grade mathematics. The supplementary materials used were--mathematical objects, filmstrips, and films.

Remmer's Test of Attitude Toward Any School Subject and the Iowa Tests of Basic Skills in mathematics were given before any phase of the program began (pre-test) and again when all phases of the study were completed (post-test). In order to evaluate the effectiveness of the three areas of teaching using supplementary materials, three different subject areas were taught so that mathematical objects, filmstrips, and films could each be used and evaluated separately. The appropriate section of the Stanford Diagnostic Arithmetic Test was administered before the instruction began in each subject area (pre-test) and again when the instruction was finished in each subject area (post-test).

Six classes, consisting of 136 students, completed the forty-six days of study. Students in two of the classes were grade-level or above, students in two of the classes were below grade-level, and students in two of the classes were below grade-level, grade-level, or above grade-level.

The specific variables which were measured were---attitude toward mathematics, mathematical concepts, problem solving ability, understanding common fractions, computation of common fractions, decimal fractions and per cent, concepts of numbers and numerals (number system and operations), concepts of numbers and numerals (decimal place value). Statistical analysis of variance was used to determine if statistical significance existed between the mean gains of the groups, from pre-test to post-test, on the basis of the twenty-four hypotheses. In the ten instances which revealed such significance, Fisher's t was applied to test the significance. The .05 level of significance was designated as the point of rejection of the statistical null hypothesis in terms of the value needed for a one-tailed test.

Conclusions based upon the findings are as follows:

1. Students who were taught mathematics with the use of supplementary materials did not show a significant gain in attitude over those who were taught by the traditional method.

2. The use of supplementary materials for teaching mathematics is not significantly effective when used for teaching students who are achieving below grade level.

3. The students progressed in ways that were more alike than in ways that were different.

4. Using supplementary materials to teach understanding and concepts of mathematics to heterogeneously grouped students produces a significant gain over those who are grouped heterogeneously and taught by the traditional method.

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CHAPTER I

INTRODUCTION

American educators have neglected the area of compensatory education far too long. Johnson said:

> To realize how negligent American education has been in facing the problems of teaching the culturally disadvantaged, one has only to examine the Encyclopedia of Educational Research over the past twenty years. Up to 1960 there is scarcely any mention of the culturally disadvantaged students (12, p. 3).

The solution to this problem seems even more urgent when we realize that, according to statistics, this population is increasing. Much of the recent research of disadvantaged pupils has consisted of identifying and listing the characteristics of these pupils and contrasting them with other pupils. Johnson stated:

> More basic research is needed to determine effective techniques for teaching culturally disadvantaged pupils. Just because an approach is 'new' does not ensure its effectiveness (12, p. 5).

Research specialists, administrators, and teachers are cooperating in their efforts to determine what should be included in the curriculum for the disadvantaged youngsters and the best ways of presenting these materials to the students. This study examined a possible solution to the problem of adequately meeting some of the needs of our disadvantaged students in one academic area.

Statement of the Problem

The problem considered was a study of the effect of supplementary materials upon academic achievement and attitude toward mathematics of eighth grade pupils.

Purpose of the Study

The purpose of this study was to examine the effectiveness of using supplementary materials in the teaching of eighth grade mathematics. The study considered the effect that supplementary materials had on students in terms of the following variables--attitude toward mathematics, mathematical concepts, problem solving ability, understanding common fractions, computation of common fractions, decimal fractions and per cent, concepts of numbers and numerals (number system and operations), and concepts of numbers and numerals (decimal place value).

Hypotheses

The following hypotheses were tested by statistical analysis of data:

1. The students in the experimental, heterogeneous, regular-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in attitude toward mathematics on Remmer's _Test of Attitude Toward Any School Subject_ than will the students in the control, heterogeneous, regular-size class who were taught by the traditional method.

2. The students in the experimental, homogeneous, regular-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in attitude toward mathematics on Remmer's Test of Attitude Toward Any School Subject than will the students in the control, homogeneous, regular-size class who were taught by the traditional method.

3. The students in the experimental, homogeneous, small-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in attitude toward mathematics on Remmer's Test of Attitude Toward Any School Subject than will the students in the control, homogeneous, small-size class who were taught by the traditional method.

4. The students in the experimental, heterogeneous, regular-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in mathematical concepts on the Iowa Tests of Basic Skills in mathematics than will the students in the control, heterogeneous, regular-size class who were taught by the traditional method.

5. The students in the experimental, homogeneous, regular-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in mathematical concepts on the Iowa Tests of Basic Skills in

mathematics than will the students in the control, homogeneous, regular-size class who were taught by the traditional method.

6. The students in the experimental, homogeneous, small-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in mathematical concepts on the Iowa Tests of Basic Skills in mathematics than will the students in the control, homogeneous, small-size class who were taught by the traditional method.

7. The students in the experimental, heterogeneous, regular-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in problem solving ability on the Iowa Tests of Basic Skills in mathematics than will the students in the control, heterogeneous, regular-size class who were taught by the traditional method.

8. The students in the experimental, homogeneous, regular-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in problem solving ability on the Iowa Tests of Basic Skills in mathematics than will the students in the control, homogeneous, regular-size class who were taught by the traditional method.

9. The students in the experimental, homogeneous, small-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in problem solving ability on the Iowa Tests of Basic Skills in mathematics than

will the students in the control, homogeneous, small-size class who were taught by the traditional method.

10. The students in the experimental, heterogeneous, regular-size class, when teaching was supplemented with mathematical objects, will show a significantly greater mean gain in understanding common fractions on the <u>Stanford Diagnostic Arithmetic Test</u> than will the control, heterogeneous, regular-size class when taught by the traditional method.

11. The students in the experimental, homogeneous, regular-size class, when teaching was supplemented with mathematical objects, will show a significantly greater mean gain in understanding common fractions on the <u>Stanford Diagnostic Arithmetic Test</u> than will the control, homogeneous, regular-size class when taught by the traditional method.

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13. The students in the experimental, heterogeneous, regular-size class, when teaching was supplemented with mathematical objects, will show a significantly greater mean gain in computation of common fractions on the <u>Stanford Diagnostic Arithmetic Test</u> than will the control, hetero-

geneous, regular-size class when taught by the traditional method.

14. The students in the experimental, homogeneous, regular-size class, when teaching was supplemented with mathematical objects, will show a significantly greater mean gain in computation of common fractions on the *Stanford Diagnostic Arithmetic Test* than will the control, homogeneous, regular-size class when taught by the traditional method.

15. The students in the experimental, homogeneous, small-size class, when teaching was supplemented with mathematical objects, will show a significantly greater mean gain in computation of common fractions on the *Stanford Diagnostic Arithmetic Test* than will the control, homogeneous, small-size class when taught by the traditional method.

16. The students in the experimental, heterogeneous, regular-size class, when teaching was supplemented with filmstrips, will show a significantly greater mean gain in decimal fractions and per cent on the *Stanford Diagnostic Arithmetic Test* than will the control, heterogeneous, regular-size class when taught by the traditional method.

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19. The students in the experimental, heterogeneous, regular-size class, when teaching was supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (number system and operations) on the Stanford Diagnostic Arithmetic Test than will the control, heterogeneous, regular-size class when taught by the traditional method.

20. The students in the experimental, homogeneous, regular-size class, when teaching was supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (number system and operations) on the Stanford Diagnostic Arithmetic Test than will the control, homogeneous, regular-size class when taught by the traditional method.

21. The students in the experimental, homogeneous, small-size class, when teaching was supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (number system and operations) on the Stanford Diagnostic Arithmetic Test than will the control,

homogeneous, small-size class when taught by the traditional method.

22. The students in the experimental, heterogeneous, regular-size class, when teaching was supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (decimal place value) on the _Stanford Diagnostic Arithmetic Test_ than will the control, heterogeneous, regular-size class when taught by the traditional method.

23. The students in the experimental, homogeneous, regular-size class, when teaching was supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (decimal place value) on the _Stanford Diagnostic Arithmetic Test_ than will the control, homogeneous, regular-size class when taught by the traditional method.

24. The students in the experimental, homogeneous, small-size class, when teaching was supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (decimal place value) on the _Stanford Diagnostic Arithmetic Test_ than will the control, homogeneous, small-size class when taught by the traditional method.

Background and Significance of the Study

"One of the major problems of American education today is to help the culturally disadvantaged pupil achieve in school in spite of his impoverished background (12, p. 1)."

Even though the average IQ for the disadvantaged is below average, some have the mental capacity to become advantaged (12, p. 9).

Effective communication with compensatory students is a major problem because they experience difficulty in all areas of communication skills. Rosengarden (26) found audio-visual instruction helpful in the ghetto schools. Teachers' subjective evaluations revealed the following effects of an audio-visual program--improved teacher preparation and planning, provided for individual differences, extended pupils' experiential backgrounds, increased pupil motivation, made subject content more meaningful and exciting, enhanced pupil self-pride, improved attitudes toward learning situations, increased pupil involvement, and encouraged pupil participation.

Johnson (11, p. 23) investigated the effectiveness of films and filmstrips in promoting learning in geometry and found there were no significant differences between methods of instruction. The one outcome for which results were consistently in favor of the experimental groups was in the retention of learning in those classes using three filmstrips and three sound films for the study of the geometry of the circle. He concluded that audio-visual aids which are developed for use in mathematics classes might be more effective as aids to learning if they were designed to supplement rather than repeat the type of instruction which the students have in the typical mathematics classroom.

Swick (28) did a study on "multi-sensory" teaching that involved 404 children in grades two through five, divided into fifteen groups, and involving fifteen teachers. The findings of the study gave strong support for the desirability of using multi-sensory aids in teaching both arithmetical computation and reasoning; however, the success of the program was revealed in better attitude toward arithmetic and in continued use of multi-sensory aids. With the exception of the fourth and fifth grade pupils high in arithmetical achievement, there were no findings to suggest possible values for pupils either high or low in achievement. The findings failed to suggest that the experimental program had special values for either high or low intellectual ability. During the experimental period, the attitude toward arithmetic improved for the second and third grade pupils. This indicated a value in beginning a multi-sensory program in the early grades.

Hall (10) used a "Concept Method" to teach ninety-seven children ages eight to twelve, during a summer camp. A follow up activity was planned to reinforce each concept with extensive use made of models and aids as well as total environment. She found that students responded in a positive manner and showed a positive change in attitude. Her method was more effective with the fifth graders than with the fourth graders. This contradicted Swick's study which indicated this type of program was better for younger students.

Educational programs for disadvantaged junior high school students in cities with populations in excess of 250,000 each were investigated by Conner (2). She found one-fifth of the cities had work-study programs and another one-fifth planned to have similar programs soon, 97 per cent of the schools had reading programs and 85 per cent had employed additional reading teachers, three-fourths of the classes used regular textbooks with supplementary materials, and over two-thirds of the cities offered summer programs. Two-thirds of these so-called "special programs" were only a modification of the previous program.

Three-fourths of the principals reported that the program improved students' attendance, behavior, and attitudes, as well as raised their aspirations. Most schools planned to expand their programs as soon as additional funds were available.

Engel (7) studied automated instructional devices for aiding culturally deprived students. In general, teachers and students agreed that the large highly automated devices were more popular than the small less automated devices. Initial high enthusiasm soon dropped off but there was a fairly high rate of interest during the ten week pilot study. Some low achievers caused disturbances if not closely supervised. The students preferred working in small groups rather than individually. His conclusion was that automation can be helpful in promoting achievement in compensatory classes.

Kostiuk (18) did a study on the effect of school environment on attitude changes of culturally deprived school children in a large metropolitan gray areas project. He concluded that attitudes changed significantly toward home, school, self, and people; therefore, the school has a responsibility to provide appropriate environment.

Trueblood (30) suggested that because most culturally disadvantaged pupils are poor readers, we should promote problem-solving skills through non-verbal problems. The students could be given a number pertaining to something they are familiar with and encouraged to make up their own problems; as an example, most students are probably familiar with the odometer reading on the instrument panel of an automobile. The students should be given ample time to discover problems and solutions on their own. Those who have difficulty formulating problems could be given two numbers and asked to find out how far the automobile had traveled.

Disadvantaged pupils have difficulty when studying about the past or planning for the future because they are "present" oriented. Johnson stated:

> Disadvantaged pupils are not interested in the past. This conjecture is consistent with the cultural development of disadvantaged pupils. The past is usually unpleasant, full of hardship and bad times. On the other hand, middle-class individuals look on the past as the foundation of their present fortunate condition. Middle-class individuals tend to look at the past to determine how

> to preserve its legacy in the present and in the future. But disadvantaged individuals tend to look at the past as containing the elements of their tragedy; thus, they do not want to perpetuate the past. In addition, the conditions of deprivation force disadvantaged pupils to constantly deal with day-by-day problems to sustain existence. Thus, disadvantaged pupils' attention is consistently focused on the present. Their pre-occupation with the pressing problems of deprivation prevents them from shifting their orientation to the past (15, p. 24).

The disadvantaged pupil pursues one problem at a time. He learns better by inductive rather than deductive approaches (15, p. 26). He also gives a better response when taught by visual and physical (kinesthetic) stimuli than when he is taught by verbal and written stimuli (15, p. 23).

Michael (21) studied the relative effectiveness of what he called "inductive" and "deductive" methods for teaching the fundamental operations on real numbers. Comparisons of mean adjusted post-test scores in accuracy of computation favored the inductive method; however, the difference was not significant at the .05 level.

Many opinions have been expressed about various methods of teaching. Dodes (5, p. 163) concluded that the teacher cannot depend upon any special type of lesson, such as "supervised study," to guarantee success in teaching and learning. There is no decisive proof that any particular method of teaching (inductive, deductive, individual, group) or any particular philosophy of teaching (teacher-dominated lesson or specialized lesson) will guarantee better results than any other method or philosophy so far as achievement is concerned.

Edmiston and Braddock (6) concluded that the most interesting findings are the high percentage of students paying attention to all "methods" of teaching and the slight differences among them. Also, the data imply that pupil participation may not always be measured by how much the pupil does, what he says, or how regularly he attends class.

Gage (9) said:

> Since we do not know which set of reinforcers or which combination is most effective, differences in method must represent differences in personal preferences. Perhaps a person is likely to recommend the use of those reinforcers which are effective for him.

Terry (29) opposed grouping gifted students homogeneously because if ability sections are formed for the gifted on the basis of intelligence test scores which have a middle and upper-class bias, we are dividing our students along social class lines. He thought we could avoid this danger by considering such other factors as ambition, enthusiasm, and leadership qualities.

Barthelmess and Boyer (1) found the results of achievement tests given at the end of one school year showed statistically significant achievement in arithmetic, English, and reading for homogeneously grouped fourth and fifth grade classes in Philadelphia. This was true for all groups--high, low, and medium.

Johnson and Scriven (17) did a study involving some 70,000 pupils. The study concerned the influence of class size and class homogenity on achievement gains in grades seven and eight. A total of 130 English and 135 mathematics classes classified according to size and homogenity were examined. The reading comprehension and arithmetic test scores on the Iowa Tests of Basic Skills were used as the measures of achievement. Results indicated that gain differences in respect to class size and class variability were generally very small and inconsistent. Because two-thirds of the classes studied consisted of from twenty-three to thirty-two pupils, the largest and smallest classes (larger than 34 and smaller than 24 students) were isolated for separate comparison. Results confirmed that there was no instance of a significant difference in achievement gain even between these extreme groups. Although these tests do not measure all types of achievement, they do suggest that attention might more profitably be directed toward reducing the number of classes assigned to one teacher, than toward reducing the size of the classes themselves.

Definition of Terms

Terms which have special meaning in this study are listed below:

Regular-Size Class.--A class of thirty students.

Small-Size Class.--A class of sixteen students.

<u>Regular Math Student</u>.--A student whose grade equivalent is 8.0 or above in mathematics.

<u>Basic Math Student</u>.--A student whose grade equivalent is below 8.0 but not less than 4.0 in mathematics.

<u>Heterogeneous Regular-Size Class</u>.--Eighteen regular students and twelve basic students with an equal number of boys and girls from each group.

<u>Homogeneous Regular-Size Class</u>.--Thirty regular students with an equal number of boys and girls.

<u>Homogeneous Small-Size Class</u>.--Sixteen basic students with an equal number of boys and girls.

<u>Traditional Method of Teaching</u>.--The assignments are textbook centered with a lecture or demonstration given by the teacher who usually uses the chalkboard. Questions and answers between students and teachers are typical. The only teaching tools are the textbook, chalkboard, and paper and pencils for the students.

<u>Supplementary Materials</u>.--Mathematical objects, filmstrips, and films.

Limitations of the Study

1. The study included pupils from only one Central California school.
2. The study was concerned only with academic achievement in mathematics and attitude toward mathematics.

Basic Assumptions

1. Factors that could not be controlled such as the influences of individual teachers, other individuals, and groups outside the school were evenly distributed throughout the subjects used in this study.
2. The differences in socio-economic conditions and home backgrounds were evenly distributed throughout the subjects used in this study.
3. Race or national origin did not interfere with the validity of the study because all subjects were selected from these particular sub-groups without regard to race or national origin.
4. Subjects cooperated to the best of their ability in their responses on the evaluative instruments.
5. The instruments used to measure progress were valid for the purpose of this study.

Instruments

Three tests were used to measure the students' progress. They were the Iowa Tests of Basic Skills, Form I, in mathematics, The Purdue Master Attitude Scales by H. H. Remmers, and the Stanford Diagnostic Arithmetic Test, Level II.

The Iowa Tests of Basic Skills are a battery of eleven separate tests which are appropriate for grades three through nine. Only items of appropriate difficulty, which have been tried previously, are assigned to each test. The tests have been organized into a pattern that yields tests of uniform length and reliability (36, p. 3).

The reliability coefficients for the Iowa Tests of Basic Skills are high. They range from .84 to .96 for the major tests and from .70 to .93 for the subtests. The composite reliabilities for the whole test range from .97 to .98 for the different grades. These correlations are sufficiently high for individual diagnosis and prediction. Intercorrelations among the various subtests range from .37 to .83 with the average ranging from .60 to .70. The tests of vocabulary and reading comprehension have the highest correlation with all other subtests indicating a heavy loading of all subtests with vocabulary and reading skills (33, p. 16).

The Purdue Master Attitude Scales are composed of a series of scales which measure attitudes toward--any school subject, any vocation, any institution, any defined group, any proposed social action, any practice, any homemaking activity, individual and group morale, and the high school. Each of the scales contains seventeen statements which utilize the Thurstone attitude scaling technique. The median scale value of the statements endorsed is the attitude score. The indifference point on all scales is 6.0. Scores above 6.0 indicate a favorable attitude, scores below 6.0 an unfavorable attitude. These scales have demonstrated validity both against Thurstone's specific scales with which they show almost perfect correlations and in differentiating among attitudes known to differ among various groups. The reliability of the scales for the measurement of attitudes is .71 to .92 (35).

Those who developed the new Stanford Diagnostic Arithmetic Tests used the same care and competence that were used to produce the well-known and widely-accepted Stanford Achievement Tests. There are separate tests in reading and arithmetic, designed to provide pre-instructional identification of the fundamental skills that require special teaching attention. Norms were developed on samples of pupils at each grade level that were carefully selected to match performance of pupils in the national standardization of Stanford Achievement Tests. Grade score scales have also been developed for Reading Comprehension, Arithmetic Concepts, and Arithmetic Computation to determine an approximate performance level for pupils or groups.

A diagnostic test is evaluated with respect to the extent it can really identify problems experienced by an individual. Relatively little formal work has been done in this area for arithmetic and no direct evidence of this sort is available on Stanford Diagnostic Arithmetic Tests (34, pp. 3, 36).

Procedures for Analysis of Data

Data for the study were processed by the Computer Center at North Texas State University, using simple analysis of variance to determine if statistical significance existed between the mean gains of the groups, from pre-test to post-test, on the basis of the twenty-four hypotheses. In the instances which F was significant, then Fisher's *t* was utilized to locate the difference. The .05 level of significance was designated as the point of rejection of the statistical null hypothesis in terms of the value needed for a one-tailed test.

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CHAPTER II

REVIEW OF RELATED RESEARCH

Introduction

Most educators are familiar with the audio-visual materials that are being used in classrooms throughout the nation. The opinions as to the effectiveness of these materials are somewhat varied. McWhirter (14) indicated that visual aids contributed to the success of progressive education in the rural areas. The facts revealed in his study tend to show that in a very definite manner visual aids are valuable teaching tools and instruction has been improved by the use of visual aids.

The research done in his study also showed that teachers in various fields of study have supplemented and broadened their lesson plans with the aid of visual instruction. Teachers and students have had their interests directed into new and stimulating channels of inquiry and application through the use of visual aids.

The remainder of this chapter is divided into four parts. The first three sections refer to the supplementary materials used in this study and the fourth discusses ability grouping which was related to the classes used for the research done in this experiment.

Mathematical Objects

Several articles involving authors' personal opinions, without statistical evidence, were found in this area; however, examination of research sources revealed a very limited amount of scientific investigation. This would seem to emphasize the pressing need for further study of the effects of these materials upon students' academic achievement and attitude.

Dairy (5) designed a three-year program to find out if the use of Cuisenaire rods in kindergarten, first, and second grades improved arithmetic achievement. Testing of experimental and control groups at the end of the second year revealed that the experimental kindergarten students had performed significantly higher. Seventy-three per cent of the children in the experimental first grade and 68 per cent of the second grade group had arithmetic totals above the 80th percentile of the national norm. It was concluded that the high test scores of all three experimental groups indicated that the use of rods did improve arithmetic achievement.

Vest (24) conducted a study on the delineation and subsequent application of a system of theoretical concepts to be imposed on the area of teaching addition, subtraction, multiplication, and division of whole numbers through the use of models of these operations. Among the major findings of the study was the system of theoretical concepts which involved an analysis of models at a general level, a characterization of the representational relationship between models, and the operations on the whole numbers at an abstract level. He also investigated the general manipulations and relations on models, and the psychological states and processes associated with learning the operations of arithmetic with the aid of models. He concluded that models do have a positive educational significance in mathematics programs.

English (10) was interested in comparing and evaluating the learning achievements of second and fifth grade pupils to determine if there was a significant difference when they studied selected units of science and arithmetic through the use of colored as opposed to black and white instructional materials. The study concerned itself with two characteristics of color usage which were color for "realism" in the study of science, and color for "attention-getting" in the study of arithmetic.

Second and fifth grade students did not realize statistically significant gains when they used colored as opposed to the black and white instructional materials in science. The second grade pupils also showed no statistically significant gains when they used the colored as opposed to the black and white instructional materials in arithmetic. There was a statistically significant advantage at the .01 level of significance in favor of the colored as opposed to the black and white instructional materials in fifth grade arithmetic. The use of color involved large blocks of color with the important arithmetic facts being overprinted on these blocks, and color to focus attention on succeeding steps of long division. The subjective opinions held by both teachers and pupils concerning a superior advantage when they were able to use colored instructional materials was supported only in the case of fifth grade arithmetic.

Filmstrips

Adair (1) attempted to determine the possible influence of filmstrip material upon a group of third grade pupils as compared with another group of third grade pupils not using filmstrip materials. The study did not show evidence of a significant gain as a result of using filmstrips. A fact that may have been significant in shaping the results of the experiment was that the scores of the control group indicated that they were superior in intelligence, word recognition, and socio-economic status according to the tests that were given in the beginning of the study.

There seemed to be an indication that filmstrips stimulated the experimental group to gainful activity so that there was less undesirable behavior on the part of the child. They appeared to be able to concentrate on larger units of reading material and to do the reading with understanding. Based on the results of this study, it was concluded that filmstrips do motivate learning as was indicated in reading achievement and behavior tests.

Wilkes (27) used film slides to present instruction to an experimental group while a control group was taught by the conventional approach of sketching on the chalkboard. Analysis of data revealed that the experimental group ranked higher at the .01 level of significance in informational achievement, visualization, quantity of work, and time used for presentation of instructional information. The experimental group expressed a higher positive attitude, significant at the .05 level, on Remmer's scale towards the slide film method of presentation. The one area in which there was no significant difference between the groups was in quality of work completed.

A research effort by Smith (19) was designed to investigate the effect of two degrees of immediacy of knowing the results of test answers upon the retention of knowledge transmitted by a filmstrip. Experimental group subjects in each of the three presentation schedules knew if their responses were correct immediately upon answering each test item. The control groups received knowledge of the results on the day following presentation. The students were tested again approximately three weeks after the filmstrip presentations. The test results were equivocal for the control and experimental groups.

McBeath (13) compared the relative effectiveness of a captioned filmstrip, a captioned filmstrip with narration, a sound filmstrip, and a filmograph in teaching facts and concepts. Immediate mean gains showed there was a significant difference at the .05 level between the four media. The Tukey test on the rank-ordered means, however, revealed that no one method could be considered significantly superior or inferior.

Students with higher intelligence quotients did significantly better at the .05 level than those with lower intelligence quotients and the boys did significantly better at the .01 level than the girls. It was concluded that matched groups of sixth grade students learned facts and concepts equally well from all of the four media. It appears from this study that such media differences as type of narration, musical background, camera movement, and other filmic techniques have no measurable effect on learning.

Films

Davis (6) attempted to determine the effectiveness of an instructional film in communicating information to a given classroom audience. The study involved a technique in which supplemental messages enriching the film content were rapidly superimposed upon the aural and visual elements of an instructional film presentation. The experimenter sought to discover the extent to which subjects presented such communication would be able to respond correctly to questions about the supplemental information, which means or combination of means of superimposition would prove most effective in delivering messages, and in what ways, if any, supplemental information presented in these ways would tend to interfere with reception of the film's message.

No significant difference was found in the total amount of information received; however, analysis of the items scores disclosed differences in scores for the supplemental message items significant at the .01 level of significance. Scores on those items by the three experimental groups were significantly superior to the items scores in the control group at the .05 level of significance. Subjects in the experimental groups missed significantly more of the items dealing with material upon which the supplemental messages were superimposed.

Teahan (21) showed twelve short films representing twelve successful black and white men to experimental groups of students from white and predominantly black elementary and junior high schools. Pre-testing and post-testing instruments measured the student's attitudes toward their own and opposite race and their "wished for" and predicted goals.

The effect of the films on black and white students in both a small mid-western city and in a large eastern metropolitan area was studied. The degree of prejudice in an all-white suburban junior high school increased with the level of the students' socio-economic status. These middle-class students may have perceived the successful blacks as a status threat.

In an urban junior high school with a 47 per cent white population, there was less prejudice among the middle-class students than among the lower-class students, who along with black students have a low achievement level and may have needed to rate blacks negatively to maintain what little status superiority they could claim as whites.

Black elementary students became more positive towards their own race, but expressed a significantly increased hostility towards whites. Also, black elementary and junior high students predicted for themselves a higher vocational level in terms of already stated "wished for" goals.

Miller (16) examined the hypotheses that film motion increases audience emotional involvement, increases positive attitude response to the film, and does not affect audience information retention. Other hypotheses were that the (GSR) Galvanic Skin Response was useful for evaluating film audience emotional involvement, that audience involvement response was positively related to attitude response, and that neither emotional involvement nor attitude responsewas significantly related to information retention.

The results of the study showed the movement groups scored significantly higher on attitude evaluation of the film but not on emotional response to the film as measured by GSR. A rise in GSR ratings indicates GSR may be a useful measure of audience response. The findings from earlier studies of no significant difference in informational learning between motion picture and filmstrip was again supported.

Motion pictures and printed communications which illustrated practical applications of mathematical concepts were used by Tiemens (22) in an attempt to investigate a better understanding of motivation and some possible means for increasing the motivation of students. First year algebra classes from seventeen Iowa high schools were randomly assigned to three treatment groups. The students in treatment group I were shown three motion picture films during the semester. The films were designed to motivate students by illustrating practical applications of algebra in various kinds of occupations. Students in treatment group II received comparable material as those in group I except that it was presented in a series of three, six to eight page, printed booklets. Treatment group III was used as a control and received no experimental treatment.

The differences found among the three treatment groups clearly favored the film treatment; however, it appeared that these differences held true for only the male subjects. The results showed the film group was superior to the control group on four of the six criterion measures and superior to the printed booklet group on three of the criterion measures. No significant differences appeared between the printed booklet group and the control group.

Ability Grouping

Even though mathematics should be taught effectively to all students (25, p. 6), we have statistical evidence that large numbers are not achieving at an acceptable rate. Stenzel (20, p. 30) reported about 10 per cent are excellent math pupils, another 10 per cent are doing a little more than might be expected of them, 40 per cent are doing satisfactory work, and the remaining 40 per cent are doing below grade level or remedial work.

One approach to providing for individual differences is ability grouping. Grouping elementary school pupils according to ability has been used in the area of reading instruction but not enough attempts have been made to determine whether ability grouping for instruction in arithmetic results in better achievement. Dewar (7) did a study in sixth grade arithmetic classes. He grouped the students high, middle, and low. He concluded that type of organization was of benefit to the high and low groups in the population studied.

A similar study was done by Morgenstorn (17). She found that academic achievement was in favor of the low intelligence group of students who were grouped homogeneously.

For the group with average intelligence, there was a significant difference in personal-social adjustment in favor of the heterogeneous group.

Mikkelson (15) conducted an experimental study to determine the effect of selective grouping and acceleration in junior high school mathematics classes. No differences resulted from grouping students of superior mathematics ability together where no adjustments were made in the procedures or curriculum. However, in cases where the curriculum was adjusted by means of acceleration a considerable savings of time was accomplished with little or no accompanying loss in mathematical skill and comprehension. There was some evidence, not conclusive, that removal of the students with superior mathematics ability from the class might be beneficial for the less able students.

Torgelson (23) obtained similar results when he compared homogeneous and heterogeneous grouping for below average junior high school students. The general conclusion was the homogeneous grouping for below-average junior high school students was not superior to heterogeneous grouping. Although it appeared to have some advantages, most of the comparisons made showed no significant differences between the two methods of grouping.

The effect of ability grouping upon individual achievement was investigated by Loomer (12). He took 493 pupils in grades four, five, and six and divided them into above average,

average, and below average classes. The evidence presented in his study indicated no decided advantage to the described method of grouping over a random method of assigning pupils to classes.

Wilcox (26) did a study to determine what effect grouping had upon the attitudes of junior high school students. He found that attitude toward school was more positive among pupils with an IQ below 104 when they were more homogeneously grouped. The grouping did not have the desired result among upper socio-economic class pupils with an IQ of 105 or higher when they were more homogeneously grouped. As a group, these students showed a more negative attitude.

The general conclusion of the majority of studies in which ability grouped classes have been compared with heterogeneously grouped classes has been "no significant difference" (2, 3, 4, 8, 9, 11, 18). This result can be at least partially contributed to the fact that the learning activities and materials to be learned were usually the same for all groups regardless of the abilities of the pupils in the classes (4, 11, 18).

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CHAPTER III

METHODS AND PROCEDURES

Subjects

The participants in this study were eighth grade students in one junior high school in a Central California community of approximately 15,000 population. The community was composed of families that represented the entire strata of socio-economic levels. Anglos, Blacks, Mexican-American, Orientals, and Portuguese lived in the community with the Anglo race being predominant.

Description of the Experimental Program

Mathematical objects, filmstrips, and films were used as supplementary materials in the experimental classes. The following mathematical objects were used: Fraction Discs for grades three through eight, by Milton Bradley Co., Springfield, Massachusetts. Kit Number 9382. The set consists of fractions of 1/8, 1/6, 1/5, 1/4, 1/3, 1/2, and 1. There are two discs in each set. One disc is a solid circle with the fractions drawn on it and the other one is cut so that each fraction is a separate piece.

Fraction Wheel by Ideal School Supply Co., Oak Lawn, Illinois. Kit Number 263. Fractions of 1/16, 1/12, 1/10, 1/9, 1/8, 1/6, 1/5, 1/4, 1/3, 1/2, and 1 are included. The rectangular cardboards have a wheel in the middle with the appropriate fractional part cut out.

Cards for Building the Meaning of Fractions, Set 2 - Meaning of Parts of a Group, by The Steck Co., Austin, Texas. Card Set 3F2. The set consists of fifty cards which have rectangles, squares, and circles. Different colors are used to illustrate the fractional parts.

Mathematical objects were used for supplementary materials when "Common Fractions" were studied. The following chart shows where the mathematical objects were used. A fifteen to twenty minute explanation of the new lesson was given by the teacher using the models in a demonstration. The remainder of the class time was used for supervised study of the assignment in the textbook.

Day of Study	Assignment in Textbook	Supplementary Materials
6	Page 131, Rows 1-10 "Written" Addition of Fractions	Fraction Discs
7	Page 132, Rows 1-6 "Written" Addition of Fractions	Fraction Wheel
8	Page 134, Rows 1-10 "Written" Subtraction of Fractions	Fraction Discs
9	Page 342, Rows 1-11 on right side of the page Subtraction of Fractions	Fraction Wheel
10	Page 125, Rows 1-10 Multiplication of Fractions	Cards
11	Page 126, Rows 1-10 Multiplication of Fractions	

Day of Study	Assignment in Textbook	Supplementary Materials
12	Page 341, Rows 1-10 on left side of the page Multiplication of Fractions	
13	Page 129, Rows 1-16 Division of Fractions	Cards
14	Page 341, Rows 1-10 on right side of the page Division of Fractions	

The following filmstrips were used: Light on Mathematics, Refresher Course, Fractions, Decimals, and Percentage, Kit 1, Filmstrip 4, Produced by the Jam Handy Organization. (59 frames).

Contents: 1. Definition of Fractions and Decimals

2. Conversion of Fractions and Decimals

3. Mixed and Improper Fractions

4. Percentage

SVE Educational Filmstrip, A 539-2, Society for Visual Education, Inc., Chicago. Using and Understanding Numbers, Per Cents, and Percentage Applications. (47 frames).

Contents: 1. Understanding the meaning and use of: Selling Price, Margin, Cost, Overhead, Profit, Loss, Original Price, Discount, and New Price.

2. Developing and understanding of the application of per cent to the items listed in the previous frames.

3. Developing an appropriate arithmetic vocabulary.

SVE Educational Filmstrip, A 538-1, Society for Visual Education, Inc., Chicago. Meaning and Reading of Decimals. (46 frames).

Contents:
1. Recognizing decimals and their use.
2. Associating decimal number symbols and oral number words.
3. Developing a fuller meaning of place value.
4. Reading and writing decimals.
5. Understanding mixed decimals and mixed numbers; pure decimals and common fractions.
6. Using Ordinal Numbers.
7. Comparing as to size.
8. Increasing and decreasing numbers.
9. Developing appropriate arithmetic vocabulary.

SVE Educational Filmstrip, A 539-1, Society for Visual Education, Inc., Chicago. Meaning and Understanding of Per Cent and Percentage. (44 frames).

Contents:
1. Recognizing the meaning of per cent.
2. Recognizing per cent and its use.
3. Associating per cent number symbols and their oral number words.

4. Developing a fuller meaning of decimals.
5. Developing a fuller meaning of the relationship of per cent to decimals and fractions.
6. Reading and writing per cents.
7. Comparing per cents as to size.
8. Increasing and decreasing per cents.
9. Developing an appropriate arithmetic vocabulary.

SVE Educational Filmstrip, A 538-5, Society for Visual Education, Inc., Chicago. Changing Fractions to Decimals -- Decimals to Fractions. (61 frames).

Contents:
1. Recognizing the interrelationship between decimal fractions and common fractions.
2. Associating decimal fraction and common fraction number symbols and oral and written number words.
3. Developing a fuller meaning of place value.
4. Reading, writing, and pointing off decimals correctly.
5. Understanding decimal fractions and common fractions.
6. Changing decimal fractions to common fractions and common fractions to decimal fractions.

7. Comparing as to size.

8. Developing an appropriate arithmetic vocabulary.

Filmstrips were used for supplementary materials when "Decimal Fractions and Per Cent" were studied. The filmstrips were shown during the first half of the class period and were discussed during their presentation. The remainder of the class time was used for supervised study of the assignment in the textbook. The following chart shows where the filmstrips were used.

Day of Study	Assignment in Textbook	Supplementary Materials
18	Page 137, All Problems Decimal Numerals	Filmstrip: Changing Fractions to Decimals - Decimals to Fractions
19	Page 138, All Problems Page 139, Rows 1-4 Add & Sub. Using Decimals	Filmstrip: Meaning and Reading of Decimals
20	Page 139, Begin at Row 5 and finish page. Addition and Subtraction Using Decimals	
21	Page 141, All Problems. Multiplication and Division of Decimals.	
22	Page 142, All Problems. Terminating Decimals.	
23	Page 143, All Problems. Repeating Decimals.	
24	Page 144, All Problems. Changing Decimals to Fractions	

Day of Study	Assignment in Textbook	Supplementary Materials
25	Page 148, All Problems. Self-Evaluation.	
26	Pages 232-233, All Problems. Ratio.	
27	Pages 235-236, All Problems. Proportion.	
28	Pages 237-238, All Problems Using Proportions and More about Rates.	
29	Pages 239, 240, 241. Per Cent and Proportion	Filmstrip: Meaning and Understanding of Per Cent and Percentage.
30	Page 242. Equivalent Fractions and Per Cents	Filmstrip: Fractions, Decimals, and Percentage.
31	Page 243, Discount, Tax, and Commission	Filmstrip: Buying and Selling Applications of Per Cent.
32	Page 246, "Self-Evaluation"	

The following films were used: Coronet Instructional Film, Decimals Are Easy, Educational Collaborator: H. G. Christofferson, Ph.D., Professor of Mathematics, Miami University. (10 Min.).

Contents:
1. Using decimals to figure money.
2. Using decimals on a road map.
3. Place Value.
4. Using decimals in addition, subtraction, multiplication, and division.

Coronet Instructional Film, The Number System and Its Structure, Educational Collaborator: Carl B. Boyer, Ph.D., Professor of Mathematics, Brooklyn College. (11 min.).

Contents: 1. Man's first record.

2. Place Value.

3. Decimal System.

4. Other Number Systems.

5. The Real Number System.

6. Closure, Associative, Commutative, and Distributive Properties.

Coronet Instructional Film, Story of Our Number System, Educational Collaborator: Herbert F. Spitzer, Ph.D., Director, University Elementary School, State University of Iowa. (11 min.).

Contents: 1. Babylonian Counting

2. Mayan Counting

3. Base 10

4. Roman Numerals

5. Place Holder Zero

6. Hindu-Arabic System

Coronet Instructional Film, The Language of Mathematics, Educational Collaborator: Harold P. Fawcett, Ph.D., Professor of Mathematics, The Ohio State University. (11 min.).

Contents: 1. Investigating social problems in the language of mathematics.

2. Mathematical Terminology

3. Grouping for Efficiency

4. Measurement Using Mathematics

Films were used for supplementary materials when "Concepts of Numbers and Numerals" were studied. A five minute preview of the film was presented by the teacher. The films were ten and eleven minutes in length and ten minutes were allowed for questions and discussion after the presentation of the film. The remainder of the class time was used for supervised study of the assignment in the textbook. The following chart shows where the films were used.

Day of Study	Assignment in Textbook	Supplementary Materials
36	Pages 5, 6, 7. Numbers and Numerals Grouping for Numeration Expanded Notation	Film: The Language of Mathematics.
37	Pages 8, 9 Base Ten Numerals Expanded Notation Using Exponents.	Film: Story of Our Number System.
38	Pages 11, 12, 13 Base 5 to Base 10 Base 10 to Base 5 Changing from Base 10 to other Bases.	
39	Pages 28, 29, 30, 31, 32 Closure Property Properties of Addition Commutative and Associative Properties Properties of Multiplication	Film: The Number System and Its Structure.
40	Pages 33, 34, 35 Properties Distributive Property More Property Problems	

Day of Study	Assignment in Textbook	Supplementary Materials
41	Page 343 Using Decimal Numerals	Film: Decimals are Easy.

(For a complete schedule of the forty-six days required for this study, see Appendix "A".)

The Control Groups' Course

The California state adopted textbook (1) was used in all classes; the content taught, therefore, was the same for all students whether in the experimental or control classes. The control groups used only the textbook, chalkboard, and pencil and paper. The assignments for the control groups were exactly the same as those for the experimental groups except no supplementary materials were used.

The Teachers

Three teachers participated in the study. They were tenured, male teachers who had taught math in this school the preceding year. Teacher "A" taught two classes, teacher "B" taught three classes, and teacher "C" taught one class. After teaching "Common Fractions" for nine days the teachers of the control and experimental classes exchanged classes. "Decimal Fractions and Per Cent" were taught for fifteen days, then the teachers returned to their original classes and taught "Concepts of Numbers and Numerals" for six days.

Lessons were carefully planned in regular meetings held between the participating teachers at least twice weekly. The teachers met briefly in the teachers' workroom each morning before classes began to review lesson plans for the day. The exact problems to be explained on the chalkboard and important terminology to be used were planned in exact detail for all classes.

Procedures for Collection of Data

Permission was obtained from the school administration to conduct the experiment. Counselors, who are responsible for programming the students, and mathematics teachers agreed to cooperate.

There were 364 eighth graders in the school where the proposed study was done. The Iowa Tests of Basic Skills in mathematics had been administered to all seventh grade students in the selected school in April, prior to the conducting of this experiment during the first semester of the 1969-1970 school term. Students new to the district were given the test at the beginning of the school term in September. These tests were given under the direction of the school counselors with the assistance of the classroom teachers. Scores were compiled and recorded by the counselors.

Sixty-four students who had scored high on these tests, who had academic grades of "A" or "B" in seventh grade arithmetic, and indicated a desire to take algebra, were enrolled in algebra classes. Eight students were enrolled in an Educationally Mentally Retarded Class, and five who scored below 4.0 grade placement were not included in the population used for this study. The 152 students that were chosen were selected from the remaining 287 students. Those who scored 8.0 and above were classified as regular math students and those who scored less than 8.0 but not less than 4.0 were classified as basic math students. They were then sub-divided into groups of boys and girls. These were arranged alphabetically and numbered chronologically in each group. These sub-groups were random sampled using a table. There were seventy-three regular math boys, sixty-six regular math girls, seventy-seven basic math boys, and seventy-one basic math girls. The study required forty-eight regular math boys, forty-eight regular math girls, twenty-eight basic math boys, and twenty-eight basic math girls.

The regular math students each had an equal chance of being selected for any one of the four classes: experimental, heterogeneous, regular-size; control, heterogeneous, regular-size; experimental, homogeneous, regular-size; or control, homogeneous, regular-size. The basic math students each had an equal chance of being selected for any one of the four classes: experimental, heterogeneous, regular-size; control, heterogeneous, regular-size; experimental, homogeneous, small-size; or control, homogeneous, small-size. A coin was tossed to determine which classes would be experimental.

A total of 136 students completed the study. Sixteen students were dropped because of change of residence, extended illness, or excessive absence. This should not affect the significance of the study because they were distributed throughout all the classes.

The school operated on a rotating class schedule; therefore, the time of day was not a variable. Each class period was forty-three minutes in length.

The <u>Iowa Tests of Basic Skills</u> in mathematics and Remmer's <u>Test of Attitude Toward Any School Subject</u> were given before any phase of the study began (pre-test) and again when all phases of the study were completed (post-test). In order to evaluate the effectiveness of each of the three areas of teaching using supplementary materials, three different subject areas were taught so that mathematical objects, filmstrips, and films could each be used and evaluated separately. The appropriate section of the <u>Stanford Diagnostic Arithmetic Test</u> was administered before the instruction began in each subject area (pre-test) and again when the instruction was finished in each subject area (post-test). The tests had items appropriate for evaluating the effectiveness of the concepts taught.

The Classes

Experimental, Heterogeneous, Regular-Size Class		Control, Heterogeneous, Regular-Size Class	
9 Regular Boys	9 Regular Girls	9 Regular Boys	9 Regular Girls
6 Basic Boys	6 Basic Girls	6 Basic Boys	6 Basic Girls
Total 30		Total 30	

Experimental, Homogeneous, Regular-Size Class		Control, Homogeneous, Regular-Size Class	
15 Regular Boys	15 Regular Girls	15 Regular Boys	15 Regular Girls
Total 30		Total 30	

Experimental, Homogeneous, Small-Size Class		Control, Homogeneous, Small-Size Class	
8 Basic Boys	8 Basic Girls	8 Basic Boys	8 Basic Girls
Total 16		Total 16	

Statistical Treatment of the Data

Data for the study were processed by the Computer Center at North Texas State University, using simple analysis of variance to determine if statistical significance existed between the mean gains of the groups, from pre-test to post-test, on the basis of the twenty-four hypotheses. In the instances which F was significant, then Fisher's t was utilized to locate the difference. The .05 level of significance was designated as the point of rejection of the statistical null hypothesis in terms of the value needed for a one-tailed test.

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CHAPTER IV

ANALYSIS OF DATA

In order to test the hypotheses of this study, a design involving a simple analysis of variance was used. The results of the analysis of variance for the three groups (there was a control class and an experimental class in each group) are presented in Tables I, II, and III.

Tables IV, V, and VI present data for the classes on Iowa Tests of Basic Skills and Stanford Diagnostic Arithmetic Test. The manual for interpreting the test scores on the Stanford Diagnostic Arithmetic Test gives grade equivalent scores only for Concepts of Numbers and Numerals. Therefore, the data for the remaining variables are not listed in the tables.

The statistical null hypotheses of no significant differences were found for hypotheses I, II, III, IV, V, VI, XI, XII, XIII, XV, XVII, XVIII, XX, and XXIII; however hypotheses VII, VIII, IX, X, XIV, XVI, XIX, XXI, XXII, and XXIV showed significant differences. It was, therefore, necessary to run t tests for these variables.

The tenability of the hypotheses of the study as set forth in Chapter I was determined by statistical analysis of the collected data. The data from the students of the six classes were punched on cards, and computations were made by the Computer Center, North Texas State University, Denton, Texas. Each null hypothesis was rejected at the .05 level of significance in terms of the value needed for a one-tailed test.

TABLE I

ANALYSIS OF VARIANCE

HETEROGENEOUS REGULAR-SIZE CLASSES

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	F Level	P	Hypothesis Number
Between	1.33	1	1.33	0.39	0.27	I
Within	176.94	52	3.40			
Total	178.27	53				
Between	4.57	1	4.57	0.19	0.34	IV
Within	1285.74	52	24.73			
Total	1290.31	53				
Between	54.67	1	54.67	3.55	0.03	VII
Within	801.65	52	15.42			
Total	856.32	53				
Between	108.37	1	108.37	10.65	0.001	X
Within	528.97	52	10.17			
Total	637.34	53				
Between	19.25	1	19.25	0.57	0.27	XIII
Within	1759.58	52	33.84			
Total	1778.83	53				
Between	290.26	1	290.26	5.23	0.013	XVI
Within	2886.57	52	55.51			
Total	3176.83	53				
Between	78.80	1	78.80	5.00	0.014	XIX
Within	819.74	52	15.76			
Total	898.54	53				
Between	41.94	1	41.94	3.74	0.03	XXII
Within	583.40	52	11.22			
Total	625.34	53				

TABLE II

ANALYSIS OF VARIANCE

HOMOGENEOUS REGULAR-SIZE CLASSES

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	F Level	P	Hypothesis Number
Between	2.39	1	2.39	0.75	0.30	II
Within	162.46	51	3.19			
Total	164.85	52				
Between	10.97	1	10.97	0.66	0.29	V
Within	846.35	51	16.60			
Total	857.32	52				
Between	50.52	1	50.52	2.82	0.048	VIII
Within	913.78	51	17.92			
Total	964.30	52				
Between	25.39	1	25.39	2.43	0.06	XI
Within	532.15	51	10.43			
Total	557.54	52				
Between	140.33	1	140.33	3.01	0.043	XIV
Within	2380.95	51	46.69			
Total	2521.28	52				
Between	20.77	1	20.77	0.59	0.28	XVII
Within	1800.71	51	35.31			
Total	1821.48	52				
Between	0.19	1	0.19	0.01	0.45	XX
Within	712.52	51	13.97			
Total	712.71	52				
Between	0.01	1	0.01	0.001	0.49	XXIII
Within	561.54	51	11.01			
Total	561.55	52				

TABLE III

ANALYSIS OF VARIANCE

HOMOGENEOUS SMALL-SIZE CLASSES

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	F Level	P	Hypothesis Number
Between	1.00	1	1.00	0.47	0.25	III
Within	54.10	27	2.00			
Total	55.10	28				
Between	17.13	1	17.13	0.80	0.31	VI
Within	592.66	27	22.00			
Total	609.79	28				
Between	71.31	1	71.31	4.38	0.02	IX
Within	439.86	27	16.29			
Total	511.17	28				
Between	0.14	1	0.14			
Within	309.86	27	11.48	0.01	0.46	XII
Total	310.00	28				
Between	22.36	1	22.36			
Within	454.81	27	16.85	1.33	0.13	XV
Total	477.17	28				
Between	78.86	1	78.86	2.54	0.059	XVIII
Within	837.90	27	31.03			
Total	916.76	28				
Between	87.03	1	87.03	8.00	0.005	XXI
Within	293.73	27	10.88			
Total	380.76	28				
Between	71.53	1	71.53	4.78	0.018	XXIV
Within	403.71	27	14.95			
Total	475.24	28				

An inspection of Tables I, II, and III disclosed that hypotheses VII, VIII, IX, XIV, XVI, XIX, XXII, and XXIV had differences large enough to be significant beyond the .05 level and hypotheses X and XXI indicated differences great enough to be significant beyond the .01 level. The analysis of variance is an overall test that indicates areas where differences exist but it does not indicate in which direction the difference lies. Fisher's t was applied to test the significance. The .05 level of significance was designated as the point of rejection of the statistical null hypothesis in terms of the value needed for a one-tailed test.

TABLE IV

DATA FOR HETEROGENEOUS REGULAR-SIZE CLASSES ON IOWA TESTS OF BASIC SKILLS AND SDAT.*

Class	Variable	Grade Equivalent Pre-Test Mean	Grade Equivalent Post-Test Mean	Grade Equivalent Gain Mean
Heterogeneous, Experimental, Regular-Size.	Mathematical Concepts on Iowa Tests of Basic Skills.	7.6 Raw Score 17	8.1 Raw Score 20	0.5
Heterogeneous, Experimental, Regular-Size.	Problem-Solving Ability on Iowa Tests of Basic Skills.	8.0 Raw Score 12	8.4 Raw Score 13	0.4
Heterogeneous, Experimental, Regular-Size.	Concepts of Numbers and Numerals on SDAT.*	6.1 Raw Score 33	6.9 Raw Score 39	0.8
Heterogeneous, Control, Regular-Size.	Mathematical Concepts on Iowa Tests of Basic Skills.	7.1 Raw Score 15	7.8 Raw Score 18	0.7
Heterogeneous, Control, Regular-Size.	Problem-Solving Ability on Iowa Tests of Basic Skills.	6.7 Raw Score 9	8.4 Raw Score 13	1.7
Heterogeneous, Control, Regular-Size.	Concepts of Numbers and Numerals on SDAT.*	6.3 Raw Score 34	6.6 Raw Score 36	0.3

*Stanford Diagnostic Arithmetic Test.

TABLE V

DATA FOR HOMOGENEOUS REGULAR-SIZE CLASSES ON IOWA TESTS OF BASIC SKILLS AND SDAT.*

Class	Variable	Grade Equivalent Pre-Test Mean	Grade Equivalent Post-Test Mean	Grade Equivalent Gain Mean
Homogeneous, Experimental, Regular-Size.	Mathematical Concepts on Iowa Tests of Basic Skills.	8.2 Raw Score 21	8.4 Raw Score 22	0.2
Homogeneous, Experimental, Regular-Size.	Problem-Solving Ability on Iowa Tests of Basic Skills.	7.2 Raw Score 10	8.4 Raw Score 13	1.2
Homogeneous, Experimental, Regular-Size.	Concepts of Numbers and Numerals on SDAT.*	7.3 Raw Score 41	8.0 Raw Score 44	0.7
Homogeneous, Control, Regular-Size.	Mathematical Concepts on Iowa Tests of Basic Skills.	8.1 Raw Score 20	8.4 Raw Score 22	0.3
Homogeneous, Control, Regular-Size.	Problem-Solving Ability on Iowa Tests of Basic Skills.	8.0 Raw Score 12	8.7 Raw Score 14	0.7
Homogeneous, Control, Regular-Size.	Concepts of Numbers and Numerals on SDAT.*	7.1 Raw Score 40	8.0 Raw Score 44	0.9

*Stanford Diagnostic Arithmetic Test.

TABLE VI

DATA FOR HOMOGENEOUS SMALL-SIZE CLASSES ON IOWA TESTS OF BASIC SKILLS AND SDAT.*

Class	Variable	Grade Equivalent Pre-Test Mean	Grade Equivalent Post-Test Mean	Grade Equivalent Gain Mean
Homogeneous, Experimental, Small-Size.	Mathematical Concepts on Iowa Tests of Basic Skills.	5.9 Raw Score 11	6.5 Raw Score 13	0.6
Homogeneous, Experimental, Small-Size.	Problem-Solving Ability on Iowa Tests of Basic Skills.	6.7 Raw Score 9	6.7 Raw Score 9	0.0
Homogeneous, Experimental, Small-Size.	Concepts of Numbers and Numerals on SDAT.*	5.2 Raw Score 25	5.3 Raw Score 26	0.1
Homogeneous, Control, Small-Size.	Mathematical Concepts on Iowa Tests of Basic Skills.	6.2 Raw Score 12	6.5 Raw Score 13	0.3
Homogeneous, Control, Small-Size.	Problem-Solving Ability on Iowa Tests of Basic Skills.	6.0 Raw Score 8	7.6 Raw Score 11	1.6
Homogeneous, Control, Small-Size.	Concepts of Numbers and Numerals on SDAT.*	4.2 Raw Score 18	5.4 Raw Score 27	1.2

*Stanford Diagnostic Arithmetic Test.

Examination of Tables IV, V, and VI revealed that all classes (with the exception of the experimental, homogeneous, small-size class in the area of "Problem-Solving Ability") showed a positive mean gain. The overall average mean gain for the classes was .7 (rounded to the nearest tenth). This indicated that the average gain was seven months for the forty-six days when compared to the national norms of one month for each twenty days taught. The control, heterogeneous, regular-size class on "Problem-Solving Ability;" the experimental, homogeneous, regular-size class on "Problem-Solving Ability;" the control, homogeneous, small-size class on "Problem-Solving Ability;" and the control, homogeneous, small-size class on "Concepts of Numbers and Numerals" showed gains of more than a year.

Hypothesis VII

The students in the experimental, heterogeneous, regular-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in problem-solving ability on the Iowa Tests of Basic Skills in mathematics than will the students in the control, heterogeneous, regular-size class who were taught by the traditional method.

TABLE VII

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HETEROGENEOUS, REGULAR-SIZE CLASSES ON PROBLEM-SOLVING ABILITY

Group	Mean Raw Score		Mean Gain	Standard Deviation	Fisher's t	Level of Significance
	Pre-Test	Post-Test				
Experimental N = 28	11.75	13.43	1.68	4.22	1.88	.05
Control N = 26	9.07	12.76	3.69	3.59		

The results of this comparison, shown in Table VII, reveal that the students in the control, heterogeneous, regular-size class had a greater mean gain in problem-solving ability than the students in the experimental, heterogeneous, regular-size class. The difference was significant at the .05 level in favor of the control group.

This indicated that supplementary materials were not helpful when used in teaching problem-solving ability to heterogeneously grouped students. There seems to be a strong implication that problem-solving ability could be taught more successfully by using the chalkboard for explanations and having the students participate in solving problems.

Hypothesis VIII

The students in the experimental, homogeneous, regular-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in problem-solving ability on the *Iowa Tests of Basic Skills* in mathematics than will the students in the control, homogeneous, regular-size class who were taught by the traditional method.

TABLE VIII

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HOMOGENEOUS, REGULAR-SIZE CLASSES ON PROBLEM-SOLVING ABILITY

Group	Mean Raw Score		Mean Gain	Standard Deviation	Fisher's *t*	Level of Significance
	Pre-Test	Post-Test				
Experimental N = 26	9.53	13.26	3.73	4.01	1.68	.05
Control N = 27	11.85	13.63	1.78	4.44		

A comparison of the experimental, homogeneous, regular-size class and the control, homogeneous, regular-size class in problem-solving ability is shown in Table VIII. The null hypothesis was rejected at the .05 level of significance. This indicated that average and above-average students show a tendency to profit from the use of supplementary materials in problem-solving ability.

Hypothesis IX

The students in the experimental, homogeneous, small-size class who have had all phases of the supplementary materials will show a significantly greater mean gain in problem-solving ability on the Iowa Tests of Basic Skills in mathematics than will the students in the control, homogeneous, small-size class who were taught by the traditional method.

TABLE IX

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HOMOGENEOUS, SMALL-SIZE CLASSES ON PROBLEM-SOLVING ABILITY

Group	Mean Raw Score		Mean Gain	Standard Deviation	Fisher's t	Level of Signif-icance
	Pre-Test	Post-Test				
Experimental N = 14	9.07	9.0	-0.07	2.92	2.09	.05
Control N = 15	8.33	11.40	3.07	4.85		

According to Table IX, a comparison of the experimental and control groups showed a significant difference in favor of the control group. This indicated that the student who is below average in grade placement and in a small class, would probably achieve more on problem-solving ability by being taught by chalkboard explanation and rote drill.

Hypothesis X

The students in the experimental, heterogeneous, regular-size class, when teaching is supplemented with mathematical objects, will show a significantly greater mean gain in understanding common fractions on the Stanford Diagnostic

Arithmetic Test than will the control, heterogeneous, regular-size class when taught by the traditional method.

TABLE X

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HETEROGENEOUS, REGULAR-SIZE CLASSES ON UNDERSTANDING COMMON FRACTIONS

Group	Mean Gain	Standard Deviation	Fisher's *t*	Level of Significance
Experimental N = 28	4.14	3.04	3.26	.01
Control N = 26	1.31	3.34		

In Table X a comparison of the experimental and control groups reveals a significant difference in favor of the experimental group. The difference was significant at the .01 level. This indicated that learning is increased by using mathematical objects to supplement teaching understanding of common fractions to a heterogeneously grouped class.

Hypothesis XIV

The students in the experimental, homogeneous, regular-size class, when teaching is supplemented with mathematical objects, will show a significantly greater mean gain in computation of common fractions on the Stanford Diagnostic Arithmetic Test than will the control, homogeneous, regular-size class when taught by the traditional method.

TABLE XI

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HOMOGENEOUS, REGULAR-SIZE CLASSES ON COMPUTATION OF COMMON FRACTIONS

Group	Mean Gain	Standard Deviation	Fisher's *t*	Level of Significance
Experimental N = 26	8.88	6.53	1.73	.05
Control N = 27	5.63	7.12		

A comparison of the experimental and control groups revealed a difference at the .05 level of significance; therefore, the null hypothesis of no significant difference was rejected. This indicated the use of mathematical objects was beneficial in teaching computation of common fractions to average and above-average students.

Hypothesis XVI

The students in the experimental, heterogeneous, regular-size class, when teaching is supplemented with filmstrips, will show a significantly greater mean gain in decimal fractions and per cent on the Stanford Diagnostic Arithmetic Test than will the control, heterogeneous, regular-size class when taught by the traditional method.

TABLE XII

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HETEROGENEOUS, REGULAR-SIZE CLASSES ON DECIMAL FRACTIONS AND PER CENT

Group	Mean Gain	Standard Deviation	Fisher's t	Level of Significance
Experimental N = 28	3.82	7.68	2.29	.05
Control N = 26	8.46	7.20		

According to Table XII, a comparison of the experimental and control groups showed a difference in favor of the control group at the .05 level of significance. This indicated filmstrips did not contribute significantly to learning when decimal fractions and per cent were taught to heterogeneously grouped students.

Hypothesis XIX

The students in the experimental, heterogeneous, regular-size class, when teaching is supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (number system and operations) on the _Stanford Diagnostic Arithmetic Test_ than will the control, heterogeneous, regular-size class when taught by the traditional method.

TABLE XIII

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HETEROGENEOUS, REGULAR-SIZE CLASSES ON CONCEPTS OF NUMBERS AND NUMERALS (NUMBER SYSTEM AND OPERATIONS)

Group	Mean Gain	Standard Deviation	Fisher's t	Level of Significance
Experimental N = 28	3.07	3.83	2.24	.05
Control N = 26	0.65	4.12		

In Table XIII a comparison of the experimental and control classes revealed a difference in favor of the experimental group at the .05 level of significance. Hypothesis XIX, as stated in the null, was therefore rejected and the research hypothesis retained. This means that a significant change did occur when films were used in a heterogeneous, regular-size class.

Hypothesis XXI

The students in the experimental, homogeneous, small-size class, when teaching is supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (number system and operations) on the Stanford Diagnostic Arithmetic Test than will the control, homogeneous, small-size class when taught by the traditional method.

TABLE XIV

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HOMOGENEOUS, SMALL-SIZE CLASSES ON CONCEPTS OF NUMBERS AND NUMERALS (NUMBER SYSTEM AND OPERATIONS)

Group	Mean Gain	Standard Deviation	Fisher's *t*	Level of Significance
Experimental N = 14	2.00	2.25	2.83	.01
Control N = 15	5.47	4.03		

In Table XIV a comparison of the experimental and control groups revealed a significant difference at the .01 level in favor of the control group. This indicated that a small size, below grade level class will achieve significantly better academically when teaching is not supplemented with films.

Hypothesis XXII

The students in the experimental, heterogeneous, regular-size class, when teaching is supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (decimal place value) on the Stanford Diagnostic Arithmetic Test than the control, heterogeneous, regular-size class when taught by the traditional method.

TABLE XV

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HETEROGENEOUS, REGULAR-SIZE CLASSES ON CONCEPTS OF NUMBERS AND NUMERALS (DECIMAL PLACE VALUE)

Group	Mean Gain	Standard Deviation	Fisher's *t*	Level of Significance
Experimental N = 28	3.07	3.70	1.93	.05
Control N = 26	1.31	2.92		

According to Table XV, a comparison of the experimental and control classes in concepts of numbers and numerals (decimal place value) showed a difference in favor of the experimental group. The null hypothesis was rejected at the .05 level of significance. This indicated that pupils in a heterogeneously grouped, regular-size class will profit from the use of films as supplementary materials.

Hypothesis XXIV

The students in the experimental, homogeneous, small-size class, when teaching is supplemented with films, will show a significantly greater mean gain in concepts of numbers and numerals (decimal place value) on the Stanford Diagnostic Arithmetic Test than will the control, homogeneous, small-size class when taught by the traditional method.

TABLE XVI

A COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS IN THE HOMOGENEOUS, SMALL-SIZE CLASSES ON CONCEPTS OF NUMBERS AND NUMERALS (DECIMAL PLACE VALUE)

Group	Mean Gain	Standard Deviation	Fisher's *t*	Level of Significance
Experimental N = 14	-0.14	3.46	2.19	.05
Control N = 15	3.00	4.21		

According to Table XVI, a comparison of the experimental and control groups showed a significant difference in favor of the control group at the .05 level. This indicates that a small size, below grade level class will be more successful academically if films are not used.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The problem of this study was to compare the academic performance and attitude of students in mathematics who were taught with the use of supplementary materials with students who were taught in a similar manner but without the use of supplementary materials. Subjects used in the study were eighth grade students enrolled in a junior high school located in Central California.

Six classes, involving 136 students, were used to collect the data. The subjects were categorized into three different kinds of classes---small-size, homogeneous; regular-size, homogeneous; and regular-size, heterogeneous. There was an experimental class and a control class in each category.

The students were compared on the following variables:

1. Attitude Toward Mathematics
2. Mathematical Concepts
3. Problem-Solving Ability
4. Understanding Common Fractions
5. Computation of Common Fractions
6. Decimal Fractions and Per Cent
7. Concepts of Numbers and Numerals (Number System and Operations)

8. Concepts of Numbers and Numerals (Decimal Place Value)

Data for the study were processed by the Computer Center at North Texas State University, using simple analysis of variance to determine if statistical significance existed between the mean gains of the groups, from pre-test to post-test, on the basis of the twenty-four hypotheses. In the instances which F was significant, then Fisher's t was utilized to locate the difference. The .05 level of significance was designated as the point of rejection of the statistical null hypothesis in terms of the value needed for a one-tailed test.

Findings

The following are the significant findings summarized in terms of the hypotheses formulated for the study:

1. The first hypothesis, which compared the regular-size, heterogeneous classes, predicted greater gains in attitude toward mathematics for the subjects in the experimental class than for the subjects in the control class. Although the experimental group did have a greater mean gain, the difference did not reach the .05 level of significance required for rejecting the null hypothesis.

2. Hypothesis 2, which predicted a significant difference between gain scores in attitude toward mathematics of the students in the regular-size, homogeneous, experimental

class and the students in the regular-size, homogeneous, control class was rejected. The experimental group showed a gain, whereas, the control group showed a loss; however, the difference did not reach the .05 level of significance required for rejecting the null hypothesis.

3. A significant gain in attitude toward mathematics for the experimental group in the-small size, homogeneous class category was predicted by the third hypothesis. Even though the experimental group showed a greater mean gain than the control group, the null hypothesis was retained when the difference failed to reach the required .05 level of significance.

4. A comparison of gains in mathematical concepts of regular-size, heterogeneous classes showed only a slight margin in favor of the experimental group. The gain was not significant at the .05 level; therefore, the null hypothesis of no significant difference was retained for the fourth hypothesis.

5. The fifth hypothesis predicted a significant gain for the experimental group in the regular-size, homogeneous class category in mathematical concepts. The gain made by the control group was greater but not significant at the .05 level; therefore, the null hypothesis of no significant difference was retained.

6. The null hypothesis of no significant difference was confirmed for the sixth hypothesis when the experimental

and control groups of the small-size, homogeneous classes were compared on mathematical concepts. The experimental group made a larger gain but not sufficient to reach the .05 level of significance.

7. The seventh hypothesis, which compared the regular-size heterogeneous classes, predicted greater gains in problem-solving ability for the subjects in the experimental class than for the subjects in the control class. The control group showed a mean gain that was significant at the .05 level that was required for rejecting the null hypothesis.

8. Hypothesis 8, which predicted a significant difference between gain scores in problem-solving ability of the students in the regular-size, homogeneous, experimental class and the students in the regular-size, homogeneous, control class was retained. The experimental group showed a gain which was significant at the .05 level that was required for rejecting the null hypothesis.

9. A significant gain in problem-solving ability for the experimental group in the small-size, homogeneous class category was predicted by the ninth hypothesis. The experimental group showed a mean loss; whereas, the control group made a significant gain. The null hypothesis of no significant difference was rejected at the .05 level of significance in favor of the control group.

10. The tenth hypothesis which predicted a significant gain for the experimental group over the control group in

understanding common fractions for the regular-size, heterogeneous classes was retained. The null hypothesis of no significant difference was rejected at the .01 level of significance.

11. The null hypothesis of no significant difference was confirmed for the eleventh hypothesis when the experimental and control groups of the regular-size, homogeneous classes were compared on understanding common fractions. The control group made a greater gain but not sufficient to reach the .05 level of significance.

12. A significant gain in understanding common fractions for the experimental group in the small-size, homogeneous class category was predicted by the twelfth hypothesis. The control group showed a greater mean gain than the experimental group; however, the gain was not sufficient to reject the null hypothesis of no significant difference at the .05 level of significance.

13. The thirteenth hypothesis, which compared the regular-size, heterogeneous classes, predicted greater gains in computation of common fractions for the subjects in the experimental class than for the subjects in the control class. The control group had a greater mean gain but the difference did not reach the .05 level of significance required for rejecting the null hypothesis.

14. Hypothesis 14, which predicted a greater mean gain in computation of common fractions by the students in the

regular-size, homogeneous, experimental class than by the students in the regular-size, homogeneous, control class was retained. The experimental group showed a greater mean gain that reached the .05 level of significance required for rejecting the null hypothesis.

15. A significant gain in computation of common fractions for the experimental group in the small-size, homogeneous class category was predicted by the fifteenth hypothesis. The control group showed a greater mean gain than the experimental group but the null hypothesis was retained when the difference failed to reach the required .05 level of significance.

16. A comparison of gains in decimal fractions and per cent of regular-size, heterogeneous classes showed a significant margin in favor of the control group. The gain was significant at the .05 level; therefore, the null hypothesis of no significant difference was rejected for the sixteenth hypothesis.

17. The seventeenth hypothesis predicted a significant gain for the experimental group in the regular-size, homogeneous class category in mathematical concepts. The gain made by the control group was greater but did not reach the .05 level of significance; therefore, the null hypothesis of no significant difference was retained.

18. The null hypothesis of no significant difference was confirmed for the eighteenth hypothesis when the experimental and control groups of the small-size, homogeneous

classes were compared on decimal fractions and per cent. The experimental group made a larger gain but not sufficient to be significant at the .05 level of significance.

19. The nineteenth hypothesis, which compared the regular-size, heterogeneous classes, predicted greater gains in concepts of numbers and numerals (number system and operations) for the subjects in the experimental class than for the subjects in the control class. The experimental group showed a gain that was significant at the .05 level of significance; therefore, the null hypothesis of no significant difference was rejected.

20. Hypothesis 20, which predicted a significant difference between mean gain scores in concepts of numbers and numerals (number system and operations) in the regular-size, homogeneous class category was rejected. The experimental group showed a small gain but not sufficient to reject the null hypothesis at the .05 level of significance.

21. A significant gain in concepts of numbers and numerals (number system and operations) for the experimental group in the small-size, homogeneous class category was predicted by the twenty-first hypothesis. The control group showed a greater mean gain that was significant at the .01 level of significance.

22. The twenty-second hypothesis which predicted a significant gain for the experimental group over the control group in concepts of numbers and numerals (decimal place value)

for the regular-size, heterogeneous classes was retained. The experimental group showed a greater mean gain that was sufficient to reject the null hypothesis of no significant difference at the .05 level of significance.

23. The null hypothesis of no significant difference was retained for the twenty-third hypothesis when the experimental and control groups of the regular-size, heterogeneous classes were compared on concepts of numbers and numerals (decimal place value).

24. A significant gain in concepts of numbers and numerals (decimal place value) for the experimental group in the small-size, homogeneous class category was predicted by the twenty-fourth hypothesis. The control group made a mean gain that reached the .05 level of significance; therefore, the null hypothesis of no significant difference was rejected in favor of the control group.

Conclusions

As a result of the findings of this study, the following conclusions have been drawn:

1. Students who are taught mathematics with the use of supplementary materials do not show a significant gain in attitude over those who are taught by the traditional method.

2. Using supplementary materials to teach understanding and concepts of mathematics to heterogeneously grouped students produces a significant gain over those who are grouped heterogeneously and taught by the traditional method.

3. Three variables produced a significant gain for the control group in the small-size classes where all students were achieving below grade level when this study began. The other five variables showed no significant difference in the small-size classes. This evidence would seem to indicate that the use of supplementary materials for teaching mathematics is not significantly effective when used for teaching students who are achieving below grade level.

4. Ten of the twenty-four hypotheses were rejected in the null form. Statistical analysis of data revealed that the subjects progressed in ways that were more alike than in ways that were different. This may account for the absence of significant differences in fourteen of the twenty-four hypotheses. This confirms the findings of a study done by Edmiston and Braddock (8, Ch. I). They concluded that the most interesting findings are the high percentage of students paying attention to all "methods" of teaching and the slight differences among them.

Recommendations

Based on the findings of this study, the following possibilities for further research are offered for consideration:

1. A study of this type should be done in a much larger school or in several smaller schools that would involve a larger number of subjects.

2. Additional research should be done involving supplementary materials other than just models, filmstrips, and films.

3. Information is needed on the effectiveness of supplementary materials in other subject areas.

4. Research needs to be done with supplementary materials at different age levels.

5. This present study should be replicated with the same teacher teaching both experimental and control subjects for all variables.

6. Information is needed on the relationship between the effectiveness of supplementary materials and teacher personality, teaching style, teacher attitudes, and teacher training in the use of supplementary materials.

APPENDIX "A"

Teaching Schedule

Day	Assignment	Supplementary Materials
1	Pre-Test on Iowa Test of Basic Skills Test A-1: Arithmetic Concepts	
2	Pre-Test on Iowa Test of Basic Skills Test A-2: Arithmetic Problem Solving	
3	Pre-Test on Purdue Master Attitude Scale	
4	Pre-Test on Common Fractions Part A: Understanding	
5	Pre-Test on Common Fractions Computation	

Common Fractions

Day	Assignment	Supplementary Materials
6	Page 131, Rows 1-10 "Written" Addition of Fractions	Fraction Discs
7	Page 132, Rows 1-6 "Written" Addition of Fractions	Fraction Wheel
8	Page 134, Rows 1-10 "Written" Subtraction of Fractions	Fraction Discs
9	Page 342, Rows 1-11 (Right side of page) Subtraction of Fractions	Fraction Wheel
10	Page 125, Rows 1-10 Multiplication of Fractions	Cards
11	Page 126, Rows 1-10 Multiplication of Fractions	
12	Page 341, Rows 1-10 (left side of page) Multiplication of Fractions	

Day	Assignment	Supplementary Materials
13	Page 129, Rows 1-16 Division of Fractions	Cards
14	Page 341, Rows 1-10 (Right side of page) Division of Fractions	
15	Post-Test on Common Fractions Part A: Understanding	
16	Post-Test on Common Fractions Part B: Computation	
17	Pre-Test on Decimal Fractions and Per Cent	
	Decimal Fractions and Per Cent	
18	Page 137, All Problems Decimal Numerals	Filmstrip: Changing Fractions to Decimals - Decimals to Fractions
19	Page 138, All Problems Page 139, Rows 1-4 Add & Sub. Using Decimals	Filmstrip: Meaning and Reading of Decimals
20	Page 139, Begin at Row 5 and finish page. Addition and Subtraction Using Decimals	
21	Page 141, All Problems. Multiplication and Division of Decimals.	
22	Page 142, All Problems. Terminating Decimals.	
23	Page 143, All Problems. Repeating Decimals.	
24	Page 144, All Problems. Changing Decimals to Fractions.	
25	Page 148, All Problems. Self-Evaluation.	

Day	Assignment	Supplementary Materials
26	Pages 232-233, All Problems Ratio	
27	Pages 235-236, All Problems Proportion	
28	Pages 237-238, All Problems Using Proportions and More about Rates.	
29	Pages 239, 240, 241. Per Cent and Proportion	Filmstrip: Meaning and Understanding of Per Cent and Percentage
30	Page 242. Equivalent Fractions and Per Cents	Filmstrip: Fractions, Decimals, and Percentage
31	Page 243. Discount, Tax, and Commission	Filmstrip: Buying and Selling Applications of Per Cent
32	Page 246, "Self-Evaluation"	
33	Post-Test on Decimal Fractions and Per Cent	
34	Pre-Test on Concepts of Numbers and Numerals. Part A: Number Systems and Operations	
35	Pre-Test on Concepts of Numbers and Numerals. Part B: Decimal Place Value	

Concepts of Numbers and Numerals

Day	Assignment	Supplementary Materials
36	Pages 5, 6, 7 Numbers and Numerals Grouping for Numeration Expanded Notation	Film: The Language of Mathematics

Day	Assignment	Supplementary Materials
37	Pages 8, 9 Base Ten Numerals Expanded Notation Using Exponents.	Film: Story of Our Number System
38	Pages 11, 12, 13 Base 5 to Base 10 Base 10 to Base 5 Changing from Base 10 to other Bases.	
39	Pages 28, 29, 30, 31, 32 Closure Property Properties of Addition Commutative and Associative Properties Properties of Multiplication	Film: The Number System and Its Structure
40	Pages 33, 34, 35 Properties Distributive Property More Property Problems	
41	Page 343 Using Decimal Numerals	Film: Decimals are Easy.
42	Post-Test on Concepts of Numbers and Numerals. Part A: Number Systems and Operations	
43	Post-Test on Concepts of Numbers and Numerals. Part B: Decimal Place Value	
44	Post-Test on Iowa Test of Basic Skills Test A-1: Arithmetic Concepts	
45	Post-Test on Iowa Test of Basic Skills Test A-2: Arithmetic Problem Solving	
46	Post-Test on Purdue Master Attitude Scale	

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