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A Study to Determine the Effectiveness of Manipulative Mathematics on Student Learning Outcomes as Compared to Textbook Practices

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**A STUDY TO DETERMINE THE EFFECTIVENESS OF MANIPULATIVE
MATHEMATICS ON STUDENT LEARNING OUTCOMES AS COMPARED
TO TEXTBOOK PRACTICES**

**A RESEARCH PROJECT
PRESENTED TO
THE FACULTY OF THE GRADUATE SCHOOL
OLD DOMINION UNIVERSITY**

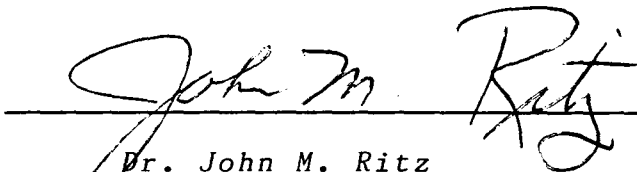
**IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE
MASTER OF SCIENCE IN EDUCATION**

**BY
CHERYL F. ROBINSON**

AUGUST, 1993

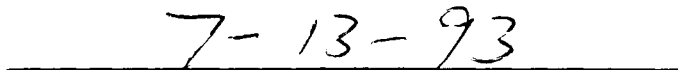
This research project was prepared by Cheryl F. Robinson under the direction of Dr. John M. Ritz in OTED 653/636, Research Methods in Education/Problems in Education. It was submitted to Dr. John M. Ritz, Research Advisor and Graduate Program Director, as partial fulfillment of the requirements for the Master of Science in Education degree.

APPROVED BY:

A handwritten signature in cursive script, reading "John M. Ritz", written over a horizontal line.

Dr. John M. Ritz
Research Advisor and Graduate Program Director
Occupational and Technical Education
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Date

A handwritten date "7-13-93" written over a horizontal line.

ACKNOWLEDGEMENTS

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MY deepest gratitude goes to my wonderful husband, Ponce, for his support, assistance, and most of all, PATIENCE. And to my family and friends...thanks for being there.

Finally, I would like to thank the fifth grade teachers and students at Malibu Elementary School for making this study possible. You know who you are!

This research study is dedicated in memory of Dr. John J. DeRolf, III, who encouraged me to pursue this degree.

Cheryl F. Robinson

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CHAPTER I

INTRODUCTION

Our technological society is expecting students to complete school with more marketable skills, particularly in the areas of problem-solving, critical thinking, and reasoning. It is essential that educators promote student interest in mathematics, focus on the intuitive capabilities of the student, teach practical uses and values of mathematics, and stimulate self-reliance and initiative in problem solving. These are fundamental in preparing and qualifying students for further education and future employment. Because many mathematics curriculums have failed to emphasize these objectives, the National Council of Teachers of Mathematics (NCTM) published two documents which addressed Curriculum (1989) and Teaching Standards (1991). Both manuals are being used across the country as guidelines for change in mathematics instruction.

Virginia Beach City Public School's Department of Instructional Support Services (1992) has developed a new manipulative mathematics curriculum which is currently being piloted in elementary schools throughout the city. It focuses on NCTM's vision that mathematics learning should be centered around problem-solving, critical thinking skills, reasoning, the use of technology, and the application of mathematics concepts to daily living. The goals of the new mathematics curriculum are predicated on the belief that all students can learn mathematics, regardless of

diverse learning styles, rates, and capabilities.

It is of significant importance that teachers realize that mathematics instruction through the use of manipulative materials makes abstract learning concrete. Using a hands-on and problem-solving approach can have a positive impact on children's understanding of mathematics concepts.

STATEMENT OF THE PROBLEM

The problem of this study was to investigate the effects of two different elementary mathematics curriculums as they impact students' learning outcomes.

RESEARCH GOALS

The hypothesis of this study was:

H0: There would be no significant difference in the learning outcomes of the students who were exposed to the manipulative mathematics curriculum as compared to those who were exposed only to textbook practices.

BACKGROUND AND SIGNIFICANCE

In 1989, the National Council of Teachers of Mathematics (NCTM) published Curriculum and Evaluation Standards for School Mathematics, a national curricula framework for mathematics. This document won widespread

support and proposed major changes in mathematics teaching. Its recent companion, *Professional Standards for Teaching Mathematics* (NCTM, 1991), elaborates the earlier documents vision of teaching in which mathematical reasoning, problem-solving, communication, and connections are central. Both of these documents, however, provide a broad framework to guide reform efforts in elementary school mathematics programs, and challenge educators to use them as a basis for change. Deborah Ball (1991), a researcher at Michigan State University, stated that-

No document, no exhortation, no program or set of materials, can, by itself, change what goes on in classrooms. Change depends on teachers working alone and together to teach in ways that help all students develop mathematical literacy and power - to teach as envisioned in the Standards documents (p.18).

With all of the changes emerging in today's society, many agree that we urgently need to reform mathematics education. Traditional methods of teaching mathematics such as textbook practices, chalk board diagrams, recitation of facts, and written drills simply do not promote the problem-solving, critical thinking, and reasoning skills emphasized in the documents published by NCTM in 1989 and 1991. The visions of NCTM's *Professional Standards for Teaching Mathematics* (1991) can be translated into reality if elementary school teachers are involved in taking leadership roles as agents of change.

Several classes (second, fourth, and fifth grades) at Malibu Elementary School in Virginia Beach, Virginia,

are piloting a new hands-on and problem-solving enhanced mathematics curriculum. It focuses on building connections between the understanding of mathematical processes through the use of concrete, representational, and symbolic manipulatives with all mathematical operations. Assessment is based on the students' ability to think hard and figure out (reason), rather than on written performance concerns. The goals and objectives of this new curriculum are based on NCTM's guidelines for mathematics instruction, and reflect the commitment of the Virginia Beach City Public Schools (VBCPS) to excellence in mathematics and to high expectations for all students (VBCPS/Department of Instructional Support Services, 1992).

Mathematics instruction in other classrooms within the school is implemented solely through the use of a commercially prepared curriculum which basically consists of textbooks, practice worksheets, and ready-made tests. The curriculum emphasizes very little, if any, hands-on practices, problem-solving skills, and reasoning skills.

The focus of this study was centered around the effects of two different curriculums used in teaching mathematics employed by two fifth grade teachers at Malibu Elementary School in Virginia Beach, Virginia. The learning outcomes of the students exposed to either approach should serve as an excellent indicator of which curriculum has the most significant impact on promoting mathematical literacy and power among all students.

LIMITATIONS

The limitations of this study were as follows:

- 1. The results of this study were confined to classes at Malibu Elementary School in Virginia Beach, Virginia.*
- 2. The study was limited to two fifth grade mathematics classes, one being exposed to the new hands-on curriculum, and the other being exposed to textbook practices only.*
- 3. The period of the study was for the second semester of the 1992-93 school year.*

ASSUMPTIONS

In this study, there were several factors which were believed to be true. They were as follows:

- 1. Students in the class implementing the hands-on curriculum had minimal exposure to using manipulatives, problem-solving strategies, and reasoning skills in mathematical operations prior to fifth grade. (Experimental group)*
- 2. Students in the class using the textbook-based curriculum had received mathematics instruction through this same approach in previous grade levels, and had minimal exposure to hands-on and problem-solving practices. (Control group)*
- 3. Both classes were composed of students with different ability levels and instructional needs.*

PROCEDURES

Two fifth grade classes at Malibu Elementary School in Virginia Beach, Virginia, were used to conduct this study. One class received mathematics

instruction through the use of the current citywide curriculum (textbook-based), and the other class used the new curriculum, which emphasizes a hands-on approach. The study was experimental in nature and was conducted as follows:

1. The class not exposed to the manipulative-enhanced math program was the control group. These students received instruction only through the use of a textbook.
2. The class exposed to the manipulative-enhanced math program were used as the experimental group. Math instruction for these students involved the initial use of hands-on materials (concrete), later reinforced through written application (abstract).
3. At an appropriate time, both classes were given identical tests which included both, computations and problem solving tasks. The results of these tests were utilized to determine the significance of two methods of teaching as they impact upon students' understanding of mathematics concepts and performance outcomes.

DEFINITION OF TERMS

The following is a list of terms and definitions that are relevant to this study.

1. **Manipulatives** - learning apparatus such as Base 10 Blocks, Tangrams, Cuisinaire Rods, Fraction Factory, Calculators, and Computers that are used by the hands in mathematics instruction.
Hands-on approach- intensified by the use of manipulatives,
Hands-on materials and **manipulatives** are used interchangeably.
2. **VBCPS** - Virginia Beach City Public Schools
3. **Curriculum** - the objectives, content, and learning sequence for a particular course.
4. **NCTM**- National Council of Teachers of Mathematics

OVERVIEW OF CHAPTER

This chapter identified the components involved in the study. It focused on two different mathematics curriculums implemented in fifth grade classes at Malibu Elementary School. The emphasis was placed on the manipulative-enhanced curriculum to which the experimental group was exposed. The problem of the study was to investigate the effects that this curriculum has on students' understanding of and performance in mathematics.

Chapter II, Review of Literature, addresses the problem in relation to similar studies done by other researchers. Chapter III, Methods and Procedures, describes the instruments and techniques used to carry out this study. Chapter IV, Findings, contains the analysis and results of the study. Lastly, Chapter V, Summary, Conclusions, and Recommendations, completes the study.

CHAPTER II

REVIEW OF LITERATURE

Mathematics instruction and student achievement has received national attention. This review dealt with past principles of mathematics instruction, and the development and implementation of the new standards for curriculum, instruction, and evaluation as outlined by the National Council of Teachers of Mathematics.

THEORETICAL BACKGROUND

This study was based on Jean Piaget's theories involving physical and logico-mathematical experiences. Physical knowledge is acquired from observing objects (empirical abstraction); whereas, logico-mathematical knowledge comes from a learner's reaction to the objects (reflective abstraction).

Piaget's theory involves four stages of development- sensory-motor, preoperational, concrete-operational, and formal operational. In each of these basic stages, individuals must absorb learned information through assimilation and adapt it to fit into their environment (accommodation). At times, these schemes are in equilibrium with the individuals environment. During each stage of

development, the individual will have a different psychological make up with which to deal with certain situations.

Elementary educators deal with children who are in the preoperational and concrete-operational stages. The age range of children in these stages is two years to eleven years. Educators need to realize that all children pass through all of Piaget's developmental stages, but they will do so at different times. A child progresses within and between stages by interacting with objects and discovering their values (empirical abstraction) and gaining control through the manipulation of objects (reflexive abstraction) (Chester, Jayne, et al., 1991, pp. 5-6).

CONTEXTS FOR CHANGE IN MATHEMATICS EDUCATION

In 1983, A Nation At Risk "awoke a sleeping nation" (p.2) to problems in our educational system (Everybody Counts, 1989). Reports showed that change was needed in virtually every aspect- curriculum, school structure, and the way that teachers are educated. Since then, mathematics instruction and student achievement has received widespread attention. Everybody Counts-A Report to the Nation on the Future of Mathematics Education (1989), reminded teachers that today's mathematics instruction should go beyond paper and pencil computations. Mathematics

curriculums should involve the use of more cooperative learning groups, and activities that require higher-order thinking skills. They should also be centered around the students' processes of mental construction and experiences, and accommodate their natural curiosities about objects, patterns, and their surroundings. "Requiring mathematics students to memorize facts and demonstrate computational mastery before they are allowed to use this knowledge at a higher level is similar to requiring music students to master all the scales before they are allowed to play 'real music' (Chancellor, 1991, p. 48). Experiencing the beauty of real music would encourage students to master their scales, just as experiencing the excitement of probability and geometry would encourage them to memorize their computation facts.

Today, more than ever before, Americans need to be able to think "mathematically" for a living. Unfortunately, most students leave school without the sufficient skills in mathematics needed to cope with on-the-job demands for problem-solving tasks. Quality mathematics education for all students is necessary in order to sustain a healthy economy. Currently, mathematical achievement among students in the United States is nowhere close to what is required to maintain our nation's leadership in a global, technological society.

For too long, America has accepted low achievement as the norm for mathematics education. "We have inherited

a mathematics curriculum conforming to the past, blind to the future, and bound by a tradition of minimum expectations" (Everybody Counts- A Report to the Nation on the Future of Mathematics, 1989, p. 1). If today's students are expected to contribute to the world of the future, educators must begin to tap into the power of mathematics.

THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS' (NCTM) ROLE IN REFORMING MATHEMATICS EDUCATION

Several attempts have been made to integrate higher-order thinking skills into mathematics curriculums. In 1986, the Board of Directors of Teachers of Mathematics (NCTM) established the Commission on Standards For School Mathematics as a means to improve the quality of mathematics education. This document contained standards for evaluating both, the mathematics curriculum and student achievement in North American schools (grades K-12).

During the 1987-88 school year, some revisions were made to the early document. The National Council of Teachers of Mathematics development of Curriculum and Evaluation for School Mathematics (1989) was designed to provide a broad framework to guide reform in school mathematics in the next decade. It envisioned what a mathematics curriculum should include in terms of content priority and emphasis (Standards, 1989).

The National Council of Teachers of Mathematics
recommendations for curriculum and evaluation called for:

- A problem-solving approach
- Appropriate language and terminology
- Connections among and between operations,
and
- Use of an approach which allows students
the opportunity to use multiple mathematical
strategies (Standards, 1989).

The Council also recommended that a greater emphasis be placed on problem-solving, mathematical reasoning, measurement, geometry, estimation, statistics, and probability. All educators interested in the quality of schools are challenged to work collaboratively to use the curriculum and evaluation standards as the basis for change so that the teaching and learning of mathematics in our schools is improved (Standards, 1989).

HELPING TEACHERS TO BECOME AGENTS FOR CHANGE

Much research supports the premise that many teachers suffer from mathematics anxiety, and often feel uncomfortable towards teaching mathematics. Because of this, they may either lack the ability to, or even avoid enriching standard curriculums. Researchers have found that the causes of elementary school teachers' high anxiety levels towards mathematics center around poor mathematics

understanding or past mathematics performance or experience. Nevertheless, teachers need to overcome their reluctance to deviate from commercially prepared curriculums (Piel and Gretes, 1992, p. 1).

For the first time ever, we have a national curricula framework that has proposed major changes in mathematics instruction. Elementary educators need to take professional responsibility for guiding the development of mathematics programs in their schools.

In order to help teachers follow the recommendations of the National Council of Teachers of Mathematics, a different instructional approach is necessary. Where do teachers begin?

First, teachers must de-emphasize paper and pencil drills, the recitation of facts, and start focusing on the exploration of mathematics through the use of manipulative materials, models, measuring tools, calculators, and computers. They must become aware of and build connections between the understanding of mathematical concepts through the use of concrete, representational materials (Professional Standards for Teaching Mathematics, 1991, p. 5).

EXPANDING THE SCOPE OF MATHEMATICS THROUGH MANIPULATIVE PRACTICES

Much emphasis is being placed on teaching practices

in mathematics. Today, one of the foremost topics in mathematics education is the use of math manipulatives. Mathematics instruction should first start with experiences that are real to the student, then it can proceed to symbolic levels. This idea is based on the five modes of presentation of concepts. The first and second modes involve the use of real world situations and manipulative models that are crucial in making learning meaningful. The third mode emphasizes the use of pictures and diagrams to bridge the concrete and abstract concepts. Lastly, the fourth and fifth modes involve the use of spoken and written symbols to teach concepts (Chester, Jayne, et al., 1991, p. 7).

TEACHERS' UNDERSTANDING AND USE OF MATH MANIPULATIVES

Math manipulatives have long been used in teaching counting and number concepts to primary age children. However, many teachers are unaware of the appropriateness of manipulative practices in all grade levels. Current research supports the use of math manipulatives, and a survey conducted by Gilbert and Bush (1988) revealed that teachers are familiar with math manipulatives, and they often have access to them for use in the classroom. Some of the manipulatives identified in the survey included counters, Cuisenaire rods, protractors, and calculators.

The survey findings concluded that the use of hands-on math materials decreased in the higher grade levels and the number of years of teaching was also a significant factor. In a similar study, Scott (1983) also found a decline in the use of manipulatives with increases in age and grade level of students. He also noted that teachers with recent orientation to manipulative use were more apt to use them (Chester, Jayne, et al., 1991, p. 8).

The authors of Teaching Mathematics in the Elementary School (Nesbit, Margolian, and Pearson, 1970) presented ways of incorporating hands-on practices into the mathematics classroom. Using geometric shapes can help children see patterns and solutions to problems. Geoboards are useful in learning direction, visual perception, and geometric properties. Number lines have been used in almost all mathematical operations. Using math manipulatives such as these can help students learn from concrete examples, then apply them to abstract concepts (Chester, Jayne, et al., 1991, p. 9).

To ensure positive results, the use of math manipulatives requires thoughtful planning on the part of the teacher. Teachers need to make sure that the manipulatives used are real and familiar to the students, and encourage students to ask questions and take risks—risks that would help them gain the mathematical power that is envisioned by the National Council of Teachers of Mathematics.

SUMMARY

The review of literature presented an overview of the efforts that educators and society have made in reforming mathematics education in our schools. It is known that mathematics' role in education is one that is especially sensitive to deficiencies in the effectiveness of the educational system. Much has already been done by legislatures, school districts, community organizations, corporations, universities, and teachers; but nevertheless, much remains to be done.

Chapter III will outline the Methods and Procedures used by the researcher. Chapter IV will review the findings that were gathered through the experimental method. Finally, Chapter V will present the Summary, Conclusions, and Recommendations of the research data.

CHAPTER III

METHODS AND PROCEDURES

This chapter describes the methods and procedures that were used in this study. The following sections were included: population, research variables, instrument design, class-room procedures, data collection procedures, statistical analysis, and summary. This research study was experimental in nature.

POPULATION

The population of this study consisted of 43 fifth grade mathematics students enrolled at Malibu Elementary School in Virginia Beach, Virginia. The control group consisted of 21 students (Class A), and the remaining 22 students made up the experimental group (Class B).

RESEARCH VARIABLES

Class A, the control group, only received mathematics instruction through the use of a commercially prepared fifth grade textbook (Mathematics - Silver Burdett, 1987).

Class B, the experimental group, was instructed through the use of a manipulative-enhanced mathematics curriculum which is currently being piloted in elementary schools

throughout Virginia Beach.

INSTRUMENT DESIGN

This study was conducted using the pretest-posttest design as developed by Silver Burdett, 1987, (Mathematics (5), Chapter 10- Fractions), (See Appendices A and B). The tests were chosen due to their availability and appropriateness for this research study. The tests were appropriate because they followed similar lesson objectives and were based on skills suitable for the fifth grade level (See Table I for Instructional Objectives).

Since Silver Burdett does not verify the measures of validity and reliability of the tests, content validity was established by matching lesson objectives to test items (See Table II for Content Validity). The only definite weakness in this design is the possible interaction between the pretest and the instruction.

PROCEDURES

This study was conducted in fifth grade classes at Malibu Elementary School in Virginia Beach, Virginia. The control group, Class A, consisted of 21 students, and the experimental group, Class B, consisted of 22 students. Mathematics sessions were conducted each morning at 9:15 A.M. and lasted approximately one hour. Prior to beginning

their units on fractions, both groups were given an identical, multiple-choice pretest (See Appendix A).

The teacher of the control group (Class A) used only textbook examples to cover the concepts presented in the unit. The lesson was taught in accordance with the textbooks' teaching suggestions, which included the reading and discussion of the text, and the demonstration of computations (using the chalkboard or overhead projector). The students were required to copy example problems in their notebooks and participate in class discussion. At the end of the lesson, students were provided independent practice drills.

The teacher of the experimental group (Class B) used a hands-on approach to teach the fractions concepts presented in the math pilot curriculum guide, which are very similar to those presented in the Silver Burdett textbook. The teacher followed the instructional format of the curriculum guide, which included introducing the lesson and demonstrating manipulative use. Student participation was mandatory. Often working in cooperative groups, the students were provided manipulatives activities that would aid in their understanding of problem-solving and computational skills (See Table III for Manipulative Activities/Materials). There was a lot of interaction among the teacher and students. Paper and pencil drills were de-emphasized and more focus was placed on reasoning and processing skills.

After completing the three-week units of study on fractions, both classes were given an identical, multiple-choice posttest (See Appendix B).

DATA COLLECTION PROCEDURES

The data was collected by computing the raw score of the two tests for each student in both groups. The two tests for both groups were compared for correlation.

STATISTICAL ANALYSIS

The data from the two tests was collected and analyzed using the t-test method. This method was used to determine whether there was a significant difference between the sample mean test scores of the control group and experimental group.

SUMMARY

Chapter III outlined the methods and procedures used to conduct this research study. They included population, research variables, classroom procedures, data collection procedures, statistical analysis, and summary. The findings and results of the study were presented in Chapter IV. The summary, conclusions, and recommendations were presented in Chapter V.

TABLE I

INSTRUCTIONAL OBJECTIVES**CHAPTER 10 - FRACTIONS (SILVER BURDETT, 1987)**

- To add or subtract like fractions
- To add and subtract like mixed numbers
- To rename like and mixed numbers before subtracting
- To add and subtract unlike fractions by naming the LCD
- To add unlike mixed numbers by using the LCD
- To subtract unlike mixed numbers by using the LCD
- To rename unlike mixed numbers before subtracting
- To use an experiment to solve a problem involving fractions

INSTRUCTIONAL OBJECTIVES
UNIT 13: ADDITION AND SUBTRACTION OF FRACTIONS
(MANIPULATIVE MATHEMATICS CURRICULUM GUIDE, 1992)

- To add two or more fractions, whole numbers, and/or mixed numbers with sums expressed in lowest terms
- To subtract two whole numbers and/or mixed numbers with differences expressed in lowest terms
- To determine when renaming fractions is necessary
- To use problem-solving strategies to solve problems involving addition and subtraction of fractions, whole numbers, and/or mixed numbers

TABLE II

VERIFICATION OF CONTENT VALIDITY OF TEST INSTRUMENTS

MANAGEMENT/ENABLING OBJECTIVES ITEMS	PRE/POSTTEST
- Adding/subtracting like fractions	1-5
- Adding/subtracting like mixed numbers	6-11
- Adding/subtracting unlike fractions	12-16
- Adding/subtracting unlike mixed numbers	17-21
- Experimenting to solve word problems	22-23
- Solving word problems that involve adding/subtracting fractions	24-25

TABLE III

MANIPULATIVE MATERIALS

*"Fraction Factory" kit
whole apples/pieces
pattern blocks
calculators
pie shapes*

EXAMPLES OF MANIPULATIVE ACTIVITIES

- *Manipulate objects ("Fraction Factory" pieces) to demonstrate addition and subtraction of fractions, whole numbers, and/or mixed numbers*
- *Expedite the computational steps in adding and subtracting two or more fractions, whole numbers, and/or mixed numbers by using the calculator*
- *Solve oral word problems involving the addition and subtraction of fractions, whole numbers, and/or mixed numbers using actual objects*

CHAPTER IV

FINDINGS

The problem of this study was to investigate the effectiveness of two different elementary mathematics curriculums as they impact student learning outcomes. This chapter contains the results of the data collected from the test instruments used in the study. The data was used to determine if there is a significant difference in the learning outcomes of the students exposed to manipulative mathematics as compared to those students who received instruction through the use of commercially prepared textbooks.

EXPLANATION OF TABLES

Two test instruments, designed by Silver Burdett (1987), were given to both classes and used to collect data. Both the Pretest and Posttest (Test 1 and Test 2, respectively) consisted of adding and subtracting like and unlike fractions, and experimental problem solving tasks. The number of correct responses on the test were recorded for comparison by the researcher. A t-Test was computed to compare the results of the two tests (See Tables IV and V).

The pretest and posttest scores of both classes were

tabulated and the mean scores were calculated. Using the mean scores of each class and both tests, a t-Test was computed to determine if there was a statistically significant difference between the means. The mean scores of the class using textbook practices (Control Group/Class A) were: Pretest, 51.2, and Posttest, 83.4, compared to those of the class exposed to manipulative practices (Experimental Group/Class B), Pretest, 30.4, and Posttest 65.6. The t-Test comparison results were determined to be: Pretest, 4.62, and Posttest, 3.87. The calculated t-ratio indicated that the values exceeded at both, the .01 and .05 levels of significance, using the total number of students and "Table II Critical Values of t", (Tuckman, 1988, p. 476). (See Tables IV and V).

SUMMARY

Chapter IV gave the results of the two tests that were administered to gather data. The data was recorded, and the mean scores for both group's pretest and posttest were calculated. A t-Test was computed to determine if a significant difference existed between the means. Chapter V will provide the Summary, Conclusions, and Recommendations of the study.

TABLE IV

RESEARCH DATA - PRETEST

<u>CONTROL GROUP (A)</u>	<u>EXPERIMENTAL GROUP (B)</u>
84	60
88	40
76	36
76	36
68	36
64	36
60	32
60	32
56	32
56	32
44	28
44	28
40	28
40	28
40	28
36	24
32	24
32	24
28	24
28	24
24	20
	16
-----	-----
$N = 21$	$N = 22$
$\bar{X} = 51.2$	$\bar{X} = 30.4$

t-Test Results

$$t = \frac{20.8}{\sqrt{20.2}} = \frac{20.8}{4.5} = 4.62$$

TABLE V

RESEARCH DATA - POSTTEST

CONTROL GROUP (A)

100
96
96
96
96
96
92
92
92
92
88
88
88
84
80
80
76
76
56
48
48

$N = 20$
 $\bar{X} = 83.4$

EXPERIMENTAL GROUP (B)

92
88
88
84
76
72
72
72
64
60
60
60
60
60
60
60
56
56
52
52
40

$N = 22$
 $\bar{X} = 65.6$

t-Test Results

$$t = \frac{17.8}{\sqrt{21.19}} = \frac{17.8}{4.6} = 3.87$$

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The problem of this study was to investigate the effectiveness of two different elementary mathematics curriculums as they impact the learning outcomes of fifth grade students at Malibu Elementary School, Virginia Beach, Virginia.

The hypothesis of this study was that there would be no significant difference in the learning outcomes of the students who were exposed to manipulative-enhanced mathematics and those who were exposed only to textbook practices.

Two separate classes were used to complete this study. The results of the two grade-appropriate fractions tests (Silver Burdett, 1987, Chapter 10) were used to determine whether one instructional approach was better than the other concerning the learning outcomes of students.

The mean scores of the pretest and posttest for both the control group and the experimental group were calculated and a t-Test was computed. This method was used to determine if there was a significant difference between the two means both groups and both tests.

CONCLUSIONS

The findings of this study showed that there was, indeed, a significant difference in student learning outcomes between the control group and the experimental group. According to the data presented in Chapter IV, the mean scores of the control group were: Pretest, 51.2, and Posttest, 83.4, compared with the mean scores of the experimental group: Pretest, 30.4, and Posttest, 65.6. These scores were used to compute the t-Test which was used to determine the level of significance.

As seen in Chapter IV, the results of the t-Test were: Pretest, 4.62, and Posttest 3.87. The values for the computed t-ratios exceeded both, the .01 and .05 levels of significance.

The control group exposed to textbook instruction scored significantly higher (on the pretest and posttest) than the experimental group using manipulative practices. Therefore, the researcher was not able to accept the hypothesis that there would be no significant difference in the learning outcomes of the students in the control and experimental groups. The null hypothesis was rejected.

RECOMMENDATIONS

Many times during our work experiences with students,

we often form opinions based on learning outcomes, ideas or conclusions of others, and our personal feelings about the subjects we teach. We can only confirm our ideas by submitting them to further investigation.

Based on the research findings and conclusions, the researcher suggests the following recommendations:

1. That additional research is needed to determine which instructional approach used in this study is more or less effective concerning student learning outcomes
2. That further research should be conducted among other Virginia Beach City Public Schools implementing the manipulative mathematics curriculum and those continuing textbook practices
3. That further research should be conducted using a testing instrument that would include problems involving logical and visual thinking strategies, experiments, the use of patterns, and mental math strategies, rather than written computations
4. That research is carried out over the course of the school year to determine whether there is a consistency in student learning outcomes, particularly in other math topics

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APPENDICES

APPENDIX A.
PRETEST

Choose the correct answer for each.

1. $\begin{array}{r} \frac{3}{6} \\ + \frac{2}{6} \\ \hline \end{array}$	A $\frac{6}{5}$ B $\frac{5}{6}$ C $\frac{1}{5}$ D not given	8. $5\frac{3}{4} + 3\frac{2}{4}$	A $2\frac{1}{4}$ B $8\frac{1}{4}$ C $9\frac{1}{4}$ D not given
2. $\frac{7}{8} - \frac{3}{8}$	A $\frac{1}{2}$ B $\frac{4}{7}$ C $\frac{10}{8}$ D not given	9. $\begin{array}{r} 3\frac{1}{2} \\ + 1\frac{1}{2} \\ \hline \end{array}$	A 5 B 4 C 2 D not given
3. $\frac{14}{25} + \frac{6}{25}$	A $\frac{8}{25}$ B $\frac{25}{20}$ C $\frac{4}{5}$ D not given	10. $\begin{array}{r} 7\frac{3}{6} \\ - 4\frac{5}{6} \\ \hline \end{array}$	A $2\frac{6}{8}$ B $3\frac{1}{3}$ C $2\frac{2}{3}$ D not given
4. $\begin{array}{r} \frac{9}{10} \\ - \frac{6}{10} \\ \hline \end{array}$	A $\frac{4}{10}$ B $\frac{1}{3}$ C $\frac{10}{15}$ D not given	11. $\begin{array}{r} 6 \\ - 1\frac{5}{12} \\ \hline \end{array}$	A $5\frac{7}{12}$ B $4\frac{7}{12}$ C $7\frac{5}{12}$ D not given
5. $\frac{1}{9} + \frac{3}{9} + \frac{3}{9}$	A $\frac{4}{9}$ B $\frac{7}{9}$ C $\frac{3}{4}$ D not given	12. $\begin{array}{r} \frac{1}{2} \\ + \frac{1}{8} \\ \hline \end{array}$	A $\frac{7}{8}$ B $\frac{3}{4}$ C $\frac{3}{8}$ D not given
6. $\begin{array}{r} 4\frac{3}{5} \\ + 2\frac{1}{5} \\ \hline \end{array}$	A $7\frac{1}{5}$ B $6\frac{4}{5}$ C $2\frac{2}{5}$ D not given	13. $\begin{array}{r} \frac{3}{4} \\ - \frac{2}{3} \\ \hline \end{array}$	A $\frac{1}{12}$ B $\frac{1}{3}$ C $\frac{1}{4}$ D not given
7. $\begin{array}{r} 8\frac{5}{8} \\ - 7\frac{3}{8} \\ \hline \end{array}$	A $\frac{2}{8}$ B $1\frac{8}{8}$ C $1\frac{1}{4}$ D not given	14. $\frac{2}{5} + \frac{3}{10}$	A $\frac{3}{5}$ B $\frac{5}{10}$ C $\frac{7}{10}$ D not given

Choose the correct answer for each.

$$15. \begin{array}{r} \frac{7}{9} \\ - \frac{1}{3} \\ \hline \end{array}$$

A $\frac{6}{9}$
B $\frac{4}{9}$

C $\frac{8}{9}$
D not given

$$16. \begin{array}{r} 6\frac{2}{3} \\ - 1\frac{1}{2} \\ \hline \end{array}$$

A $5\frac{1}{3}$
B $5\frac{1}{6}$

C $4\frac{2}{3}$
D not given

$$17. 2\frac{7}{12} + 7\frac{1}{3}$$

A $9\frac{11}{12}$
B $9\frac{5}{6}$

C $10\frac{1}{12}$
D not given

$$18. \begin{array}{r} 8\frac{1}{4} \\ - 2\frac{1}{5} \\ \hline \end{array}$$

A $10\frac{9}{20}$
B $6\frac{1}{10}$

C $6\frac{1}{20}$
D not given

$$19. \begin{array}{r} 3\frac{5}{8} \\ + 4\frac{3}{4} \\ \hline \end{array}$$

A $7\frac{8}{11}$
B $8\frac{3}{8}$

C $8\frac{7}{8}$
D not given

$$20. 15\frac{1}{2} - 11\frac{5}{6}$$

A $3\frac{2}{3}$
B $3\frac{5}{6}$

C $4\frac{4}{6}$
D not given

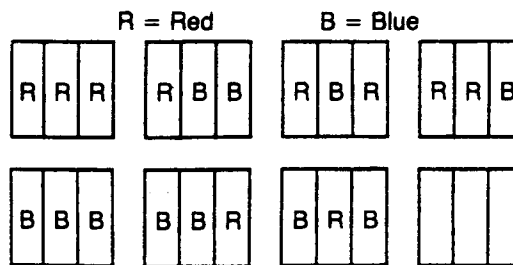
$$21. \begin{array}{r} 9\frac{3}{16} \\ - 4\frac{3}{8} \\ \hline \end{array}$$

A $5\frac{3}{16}$
B $4\frac{13}{16}$

C $4\frac{3}{4}$
D not given

Experiment to solve 22–23.

Marie wants to paint 3 vertical stripes in a design. She will use only red and blue stripes. She experiments with the colors and finds that there are 8 different possible designs. Seven of the 8 designs are completed below.



22. What colors will the stripes be in the eighth design?

A blue, red, red C blue, red, blue
B blue, blue, blue D not given

23. What fraction of the designs will have exactly 2 blue stripes?

A $\frac{3}{7}$ C $\frac{3}{8}$
B $\frac{1}{2}$ D not given

Solve.

24. Naomi uses 160 colored beads to make a necklace. 120 of the beads are red. What fraction of the beads are red?

A $\frac{16}{12}$ C $\frac{2}{3}$
B $\frac{3}{4}$ D not given

25. Mr. Rodriguez bought $\frac{1}{5}$ of the necklaces on sale at the fair. Mrs. King bought $\frac{1}{4}$ of them. What fraction of the necklaces did they buy in all?

A $\frac{1}{10}$ C $\frac{3}{10}$
B $\frac{2}{5}$ D not given

APPENDIX B.
POSTTEST

Choose the correct answer for each.

1. $\begin{array}{r} \frac{2}{5} \\ + \frac{1}{5} \\ \hline \end{array}$	A $\frac{5}{3}$ B $\frac{3}{5}$ C $\frac{1}{5}$ D not given	8. $5\frac{2}{3} + 2\frac{2}{3}$	A $7\frac{1}{3}$ B $8\frac{1}{3}$ C 3 D not given
2. $\frac{8}{9} - \frac{2}{9}$	A $\frac{1}{3}$ B $\frac{6}{8}$ C $\frac{10}{9}$ D not given	9. $\begin{array}{r} 4\frac{3}{4} \\ + 1\frac{1}{4} \\ \hline \end{array}$	A $3\frac{1}{2}$ B 5 C 6 D not given
3. $\frac{13}{24} + \frac{5}{24}$	A $\frac{24}{18}$ B $\frac{3}{4}$ C $\frac{8}{24}$ D not given	10. $\begin{array}{r} 5\frac{2}{5} \\ - 1\frac{4}{5} \\ \hline \end{array}$	A $3\frac{3}{5}$ B $4\frac{2}{5}$ C $3\frac{5}{6}$ D not given
4. $\begin{array}{r} \frac{11}{12} \\ - \frac{6}{12} \\ \hline \end{array}$	A $\frac{12}{17}$ B $\frac{1}{2}$ C $\frac{5}{12}$ D not given	11. $\begin{array}{r} 8 \\ - 2\frac{6}{8} \\ \hline \end{array}$	A $6\frac{2}{8}$ B $5\frac{1}{4}$ C $10\frac{6}{8}$ D not given
5. $\frac{1}{8} + \frac{3}{8} + \frac{3}{8}$	A $\frac{7}{8}$ B $\frac{4}{8}$ C $\frac{3}{4}$ D not given	12. $\begin{array}{r} \frac{1}{2} \\ + \frac{2}{10} \\ \hline \end{array}$	A $\frac{3}{5}$ B $\frac{7}{10}$ C $\frac{3}{10}$ D not given
6. $\begin{array}{r} 4\frac{3}{6} \\ + 3\frac{2}{6} \\ \hline \end{array}$	A $8\frac{1}{6}$ B $7\frac{5}{6}$ C $1\frac{1}{6}$ D not given	13. $\begin{array}{r} \frac{3}{4} \\ - \frac{1}{3} \\ \hline \end{array}$	A $\frac{1}{4}$ B $\frac{1}{2}$ C $\frac{5}{12}$ D not given
7. $\begin{array}{r} 9\frac{6}{10} \\ - 4\frac{4}{10} \\ \hline \end{array}$	A $5\frac{1}{5}$ B $5\frac{10}{10}$ C $4\frac{2}{10}$ D not given	14. $\frac{3}{8} + \frac{1}{4}$	A $\frac{5}{8}$ B $\frac{4}{8}$ C $\frac{3}{4}$ D not given

Choose the correct answer for each.

15.
$$\begin{array}{r} \frac{5}{6} \\ - \frac{1}{2} \\ \hline \end{array}$$

A $\frac{9}{12}$
B $\frac{2}{5}$

C $\frac{4}{6}$
D not given

16. $6\frac{5}{6} - 2\frac{1}{3}$

A $4\frac{4}{6}$
B $4\frac{1}{2}$

C $3\frac{5}{6}$
D not given

17. $3\frac{3}{8} + 2\frac{1}{2}$

A $6\frac{1}{4}$
B $5\frac{4}{8}$

C $5\frac{7}{8}$
D not given

18.
$$\begin{array}{r} 9\frac{1}{3} \\ - 7\frac{1}{4} \\ \hline \end{array}$$

A $2\frac{1}{12}$
B $2\frac{1}{6}$

C $2\frac{7}{12}$
D not given

19.
$$\begin{array}{r} 1\frac{3}{5} \\ + 5\frac{7}{10} \\ \hline \end{array}$$

A $7\frac{1}{10}$
B $6\frac{10}{13}$

C $7\frac{3}{10}$
D not given

20. $17\frac{1}{2} - 12\frac{2}{3}$

A $5\frac{5}{6}$
B $4\frac{2}{3}$

C $4\frac{5}{6}$
D not given

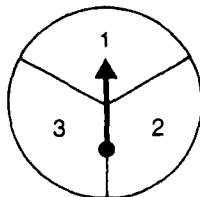
21.
$$\begin{array}{r} 8\frac{5}{12} \\ - 4\frac{5}{6} \\ \hline \end{array}$$

A $4\frac{5}{12}$
B $3\frac{7}{12}$

C $3\frac{2}{3}$
D not given

Experiment to solve 22–23.

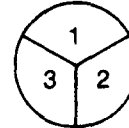
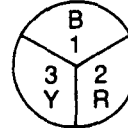
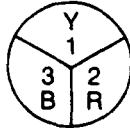
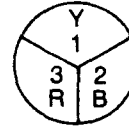
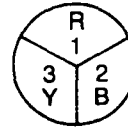
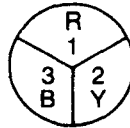
Chip wants to paint each section of this spinner a different color. He experimented and found there are 6 different ways to do this. Five of them are at the top of the next column.



R = Red

Y = Yellow

B = Black



22. What is the sixth way to paint the spinner?

- A #1- red, #2- black, #3- yellow
B #1- black, #2- yellow, #3- red
C #1- black, #2- red, #3- yellow
D not given

23. What fraction of the designs for the spinner have #2 painted red?

- A $\frac{1}{2}$
B $\frac{1}{6}$
C $\frac{2}{5}$
D not given

Solve.

24. Paco uses 90 shells to make a bracelet. 60 of the shells are clam shells. What fraction of the shells are clam shells?

- A $\frac{6}{15}$
B $\frac{9}{6}$
C $\frac{2}{3}$
D not given

25. The school fair sold 3 types of bracelets. One sixth of them were made of wood. One fifth of the bracelets were made from beads. The rest were made from metal. What fraction of the bracelets were made from metal?

- A $\frac{19}{30}$
B $\frac{11}{30}$
C $\frac{1}{3}$
D not given