

The Effect of Manipulative Use
on the
Conceptual Knowledge of Third Graders

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Table of Contents

List of Tables	i
Abstract	ii
I. Introduction	1-2
Statement of the Problem	3
Statement of Research Hypothesis	3
Operational Definitions	4
II. Literature Review	5
Manipulatives Generate New Procedures	5-6
Mathematics Instructional Strategies that Entail Manipulatives	6-7
Manipulative Use Supports Classroom Instruction	7-9
Summary	9
III. Methods	10
Design	10
Subjects	10
Instrument	11
Procedures	11
IV. Results	13
V. Discussion	14
Implications	14
Threats to Validity	14-15
Comparison of Study Results with Research	15
Future Research	15-16
References	17-18

List of Tables

- | | |
|--|----|
| 1. Grades in academic classes before and after physical education. | 13 |
|--|----|

Abstract

The purpose of this study was to determine if third grade students would achieve higher on area conceptual knowledge assessment after taking part in manipulative use interventions. The measurement tool was a ten-question assessment drafted from the Anne Arundel County Public School Quarter 3-unit assessment. This study involved use of a pretest- posttest design to measure the data collected from the participants scores. Achievement gains were higher in both groups that was measured after the interventions. Research in this area should continue. The participants showed appreciation for using color-tiles and geo-boards to learn math concepts. Research and data from this show an increase on student assessments and knowledge.

Chapter 1

Introduction

Overview

The purpose of this study is to determine if the use of manipulatives will increase mathematics conceptual knowledge of third grade students in effort to help academic achievement. Math concepts are extremely important considering that math helps students build problem-solving skills, and math is used in every career. A solid foundation in mathematics and develops and hones the skills of analyzing data, recognizing patterns, seeking evidence, conclusions and proof, solving problems, and seeking absolutes, while being open to new information. Conceptual knowledge of math in third grade will prepare students for math concepts in during their education matriculation and achievement on formal assessment. Students who are advanced in the areas of mathematics potentially will be successful in areas of science and engineering. That is why in education it is important to grasp knowledge of science, technology, engineering, and mathematics. Students who are not successful in math content will not be successful in areas such as finance and budgeting. Furthermore, the unit and topics of area and perimeter are important to mathematics because they are the physical aspects of mathematics. They are the foundation for understanding other aspects of geometry such as volume and mathematical theorems that help us understand algebra, trigonometry, and calculus.

It is clear that students provided with hands on tools and resources generate new procedures in the classroom, and support classroom instruction. The use of manipulatives allows teachers to use games, and physical representations for small group and differentiated instruction. Students can solve equations with a hands-on approach. Manipulatives promote imagination in the classroom by associating visual and objects with numbers. Manipulatives are

also for fundamental games and activities that coincide with concepts such as multiplication, geometry, equations, and area. These procedures can also be identified as differentiated instruction for English language learners, visual methods for student's hands on experiences provide modern examples of mathematics Piaget (1952). Manipulatives are a new experience for students. They provided a concrete example of items you can touch and move around that support knowledge in classification, patterning, counting, equations, fractions, multiplication, and other math tasks. These items include attribute blocks, geometric shapes, base ten blocks, unifix cubes, fraction bars, color-tiles, geo-boards, and plastic counting cubes. In third grade, students must master the standard of modeling mathematics and understand the concept of area and apply the concept to the related understanding of multiplication. Third grade mathematics instruction is based off Maryland common core standards. One of the most important standards in third grade is area, this standard is known as 3. MD.C.5. Understanding the concept of area is important as it relates to multiplication and applies to real life. The use of area has many practical applications in building, farming, architecture, and science Russell, Deb. (2018). Understanding length and width; and how multiplying the two together provides dimensions of shapes and structure is important. Students who do not understand these concepts will lack in areas of math in which they will be ill prepared for higher education and the workforce. Based on placement tests, a staggering 60 percent of U.S. students who enter community colleges are not qualified to take a college mathematics course, Wolpert (2018).

Color-tiles and geo-boards will be used as an intervention for students in third grade math. Color-tiles are small tiles in the shapes of squares and a variety of colors that students can use as columns and rows to show a representation of length times width. For example, if a student were to discover a width of three and width of seven; they would use three color tiles to

show 3 rows and then fill in each row with additional tiles to show seven columns. By using color-tiles and geo-boards students are then able to count the total number of tiles composed of each tile in the rows and columns. Students would also see three tiles in a row representing the width of three and 7 tiles in each column representing the length of seven. Manipulatives are also associated with a strategy to create a visual for multiplication; hence the problem 3×7 . The other tool for intervention is geo-boards. Geo-boards are square grids usually with a size of 10 by 10 that represent different shapes and sizes. There are pegs at the corner of each block. Students use rubber bands to build images of the shapes by placing them around the pegs on the grid. Once students have created the provided shape, they can count the number of squares inside of the shape and determine the area.

Statement of the problem

The purpose of this study is to investigate the effectiveness of using color tiles compared to geo-boards for improving Title 1 third grade students' conceptual understanding of area.

Hypothesis

There will be no difference in the calculation of area for students using color tiles compared to geo-boards in effort to increase achievement on third grade assessments.

Operational Definitions

Dependent Variable- *Achievement*

Students will be assessed with a ten-question assessment composed of area concept questions from the Anne Arundel County Public School area unit test. Questions from the assessment include multiple choice questions, written responses that require students to show their work, and students matching the right area to the correct shape.

Independent Variables- Concept of Area, color tiles, geo-boards Concept of area

Area is the measure of how much space there is on a flat surface. Different shapes have different formulas and method to find area. The concept of area will be measured through assessment.

Color-tiles

Color Tiles are a versatile collection of 1-inch square tiles that come in four colors—red, green, yellow, and blue. Color Tiles can be used to explore all the diverse ways that squares, and other shapes can be arranged, subject to certain constraint.

Geo-boards

A geoboard is a mathematical manipulative used to explore basic concepts in plane geometry such as perimeter, area and the characteristics of triangles and other polygons.

Chapter II

Literature Review

The purpose of this literature review is to explore the topic of using manipulatives to improve student achievement in mathematics; specifically, the use of color blocks and number tiles to improve third grade students' understandings of area. Researchers found that students who use concrete manipulatives as a part of instruction are far ahead of those who do not. "The use of manipulatives over a long period of time showed learners made improvements in respect of articulating mathematical thinking, discussion of mathematical concepts and ideas, thinking divergently to find alternate methods to solve problems, ability to use a number of different mathematical symbols when solving problems and making presentations and increase in confidence." (Sebesta and Martin 2004, p. 76). Section one provides an overview of manipulatives as generators of new procedures for mathematics; section two discusses mathematics instructional strategies that entail the use of manipulatives; and section three shows evidence that manipulatives impact learning.

Manipulatives Generate New Procedures

"I argue that concrete experiences are those that build on what is familiar to a child and can involve objects, verbal analogies, or virtual images" (Baroody 2017, p.24). Concrete manipulatives are a reliable source for memory prompts and visualizations. They allow the student to place familiar or unknown concepts in the context of a meaningful physical representation, making a connection between the two. This helps students recall and apply the concepts. For example, during the first marking period of third grade math instruction in Anne Arundel County educators are asked to implement a lesson involving fractions. In the instructional template the use of fraction tiles and number blocks is encouraged to further

comprehension. Baroody noted that manipulatives help children extend their informal knowledge or use their informal knowledge to understand and learn formal knowledge. Thus, manipulatives generate new procedures grounded in an informal approach to mathematics instruction.

Previously, mathematics is associated with a “paper, pencil, formula” approach or a culture of rigor that is not appealing to most. Although this is a hasty generalization, the idea is that the use of manipulatives creates a fun environment for students by motivating them via application of concrete items and representations.

There are also multiple definitions of manipulatives. Sowell (1989) conducted research on operational definitions of manipulatives, defining them in terms of concrete, pictorial, and abstract/symbolic representations. Concrete manipulatives consist of using items such as bean sticks, folded paper, and so on under the supervision of an instructor. Pictorial manipulatives are animated audio visuals and pictures. While abstract manipulatives entail regular use of paper and pencil, lectures, and notes. The concrete and pictorial representations of manipulatives opened new doors in mathematics. Pictures, audiovisuals, and objects are known more in the subjects of science, English, and social studies. By bringing these interventions into mathematics a new sense of learning is created. Now students can see pictures and videos of multiplication instead of on a printed page or use beans as a representation of equal groups. As a result, students are encouraged to use their imagination and explore mathematics.

Mathematics Instructional Strategies that Entail the Use of Manipulatives

Manipulatives supply visual and concrete representations that help students with learning disabilities. They are used as interventions and service tools for students with IEP's and 504 plans. Manipulatives are also used to cater to students' individual learning differences. Hands on experiences supply modern examples of mathematics. Piaget (1952) suggests that children begin

to understand symbols and abstract concepts only after experiencing the ideas on a concrete level.

“The evidence indicates, in short, that manipulatives can provide valuable support for student learning when teachers interact over time with the students to help them build links between the object, the symbol, and the mathematical idea both represent.” (Moore 2013, p.12)

Studies indicate that manipulatives provide significant support in instruction. Research indicates that using manipulatives is especially useful for teaching low achievers, students with learning disabilities, and English language learners (Marsh and Cooke, 1996; Ruzic and O’Connell, 2001, p. 43). Across the nation, manipulatives are stipulated as IEP interventions, prompting investments in Title 1 manipulative tools. Manipulatives as a tool for learning produces positive effects by allowing students to use concrete objects to see, model, and internalize abstract concepts. Manipulative use is recommended because it is supported by both learning theory and educational research in the classroom. Research from both learning theory and classroom studies shows that using manipulatives to help teach math can positively affect student learning. This is true for students at all levels and of all abilities (O’Connell, Ruzic 2001). The use of manipulatives is effective for all students, whether they are special education, Title 1, or ESOL. These tools are integrated into differentiated instructional strategies for all populations of students.

Manipulative Use Supports Classroom Instruction

Multiple research studies support long-term use of manipulatives in mathematics. Educators found that students make gains in the following areas such as math, geometry, and algebra. (Hedden, Picciotto 1998; Sebesta and Martin, 2004). There are many studies that show that manipulative use is effective. Some of these studies include work with counting, place value,

computation, problem solving, fractions, ratios, and algebraic abilities. All these studies found a positive impact on student achievement through the application of manipulatives.

Clements (1999) conducted a study of manipulatives involving counting. He showed that manipulative use significantly improved students' ability to count. Phillips (1989) conducted a three-year study with students in Orlando, Florida involving the use of manipulatives and logical thinking to understand place value. He concluded that manipulative use improved students' understandings of place value. Carroll and Porter (1997) focused on developing computational skills that are meaningful to students. From their research they found that "Students learning computational skills tend to master and retain these skills more fully when manipulatives are used as part of their instruction (p. 45)." Krach (1998) studied problem solving and concluded that "Using manipulatives has been shown to help students reduce errors and increase their scores on tests that require them to solve problems" (p.68). Further, students engaged with manipulatives to learn fractions outperform those who rely only on textbooks (Sebesta and Martin, 2004).

Manipulatives also align with curriculum standards. Some of these standards include sorting which is a pre-mathematical skill that aids in comprehension of patterns and functions. Ordering is a pre-mathematical skill that enhances number sense and other math-related abilities, which is a standard heavily addressed in early and elementary childhood. Distinguishing patterns is the foundation for making mathematical generalizations in effort to build for extensive math units. By distinguishing patterns with numbers students are able to build a solid foundation to learn basic addition, subtraction, multiplication, and division. Manipulatives also cover base-ten system, comprehending mathematical operations such addition, subtraction, multiplication, and division, recognizing relationships within mathematical operations, recognizing and

understanding different types of symmetry, learning about and experimenting with transformations, and problem-solving and representing mathematical ideas in a variety of ways. These standards are recognized across the nation in states such as Maryland, California, Texas, Tennessee, and North Carolina. Manipulatives are beneficial in multiple ways and areas, influencing multiple topics in classrooms across the nation.

Summary

In conclusion, research based on learning theory and conducted in classrooms indicate that manipulative use as an enhancement for learning produces a positive impact on student achievement. These results apply to students at all levels and to almost every topic covered in elementary school mathematics curricula. Papert (1980) calls manipulatives “objects to think with” (p.10). Incorporating manipulatives into mathematics lessons in meaningful ways helps students grasp concepts with greater ease, making teaching more effective.

Chapter 3

Methods

The purpose of this study was to investigate the effectiveness of using color tiles compared to geo-boards for improving Title 1 third grade students' conceptual understanding of area.

Research Design

This was an experimental design. Pre and post scores were compared for two randomly assigned groups of third grade students. The random assignment was developed by a random assignment generator. One group will be taught mathematics concepts with color-tiles and the other group will be taught using geo-boards.

Subjects

The participants of the study are students in a Title 1 school building in Anne Arundel County Public Schools. The Maryland Report Card states that in 2018 there were a total of 596 students. The population includes 247 African American students, 56 Caucasian students, 238 Hispanic students and 37 Asian students. Of the 596 students, 45% of the students speak English as a second language. 80% of the student population is FARMS (Free and reduced meals), which makes the school a targeted Title 1 population. There are various programs set up to service students such as Villa Maria for counseling, BOYS club for behaviors, and the Positive Behavior Incentive system. Only 32.9% of the student population scored proficient on the state math assessment.

The subjects taking part in the study are a total of twenty-six students. Each group consist of thirteen randomly assigned students. Group one who received interventions with color-tiles was compiled of eight boys and five girls. Out of the thirteen students, seven were African American, two were Asian, and four were Hispanic. Nine of the students were listed as FARMS. Three of

the students received English as a second language services, and one of the students had a 504 plan for behavior. Group two received interventions with Geo-boards. This group was compiled of six boys and seven girls. Out of the thirteen students, five were African American, seven were Hispanics, and one was Asian. Seven of the students in group two were listed as FARMS, while six of the students received English as a second language services.

Instrument

Student achievement was measured with an Anne Arundel County Public School Quarter Three area assessment. The assessment was compiled of five area concept questions. Question formats included student selected responses, fill in the blank questions, and written responses. AACPs requires students to provide supporting details or evidence. Therefore, students were required to show their work. The assessment aligns with common core standards CCSS.MATH.CONTENT.3.MD.C.5 “students recognize area as an attribute of plane figures and understand concepts of area measurement” and CCSS.MATH.CONTENT.3.MD.C.5.A “students understand a square with side length 1 unit, called "a unit square," is said to have "one square unit" of area, and can be used to measure area”.

Procedures

Students were provided with a five-day small group instruction intervention during math units. The interventions lasted an hour each day. There were thirty-minute sessions for group one, and thirty-minute sessions in group two. Each group began with modeled lessons that demonstrated how to use the provided manipulative effectively and appropriately. Students were given an individual bag of manipulatives (either color-tiles or geo-boards). In small groups students were administered an area concepts worksheet each day that consisted of ten area problems. Students were to answer the problems using the provided manipulatives. Students had

to informally show the instructor their work for each problem using the manipulatives. At the end of the intervention students were asked to write a written reflection telling whether color-tiles or geo-boards were helpful and if math manipulatives help them gain understanding with math concepts.

Chapter 4

Results

The purpose of this study was to investigate the effectiveness of using color tiles compared to geo-boards for improving Title 1 third grade students' conceptual understanding of area.

Two groups of third graders were taught computation of area using either color tiles or geo-boards. The pre and post-test results of the two groups were analyzed using a t-test for independent groups. The results are presented in the table below.

Table 1

Pre and post-test results for students taught using color-tiles or geo-boards.

Test	Group	Mean	N	St. Deviation	t	Significance
Pre-Test	Color Tiles	4.9	13	3.15	1.41	0.89
	Geo-Boards	5.1	13	2.36		
Post-Test	Color Tiles	7.4	13	2.14	1.41	0.89
	Geo-Boards	8.5	13	1.39		

The null hypothesis, there will be no difference in the calculation of area for students using color tiles compared to geo-boards in effort to increase achievement on third grade assessments is supported.

Chapter 5

Discussion

The purpose of this study was to investigate the effectiveness of using color tiles compared to geo-boards for improving Title 1 third grade students' conceptual understanding of area. The study showed that the participants in the study increased area concept skills from the use of color-tiles and geo-boards from pretest to posttest. There was no significant increase between the both. Both interventions increased student's post-test scores. When two separate interventions are used it expected that one of the manipulative's used would have greater significance than the other. Given pre and post-test, means and results were not statistically significant.

Implications

It is important to show the significance of manipulatives use to encourage classroom teachers to use the tools and strategies. Math lesson plans should include differentiation and resources for diverse learners. Concrete representations are necessary tools for diverse learners to improve comprehension in the classroom. Both geo-boards and color-tiles specifically can be used with area units, multiplication, and division. Maryland common core standards include these standards.

Threats to Validity

- The school building that the study took place in has a high population of students who have chronic absences. Some of the participants in the study missed some of the intervention days.
- The school also has a high population of English Language Learners who received ESOL intervention hour's one of the days during the study.

- The students in the study are also in third grade and their maturity level altered some of the participants focus.
- The school is classified Title 1 and students receive free “First in Math” lessons, first in math is a computer application for students to practice math concepts, and students also had prior knowledge of area. The study only lasted for a weeks’ time. These issues and resources may have influenced the results, other than color-tiles and geo-boards.

Comparison of Study Results with the Research

Hands on experiences provide modern examples of mathematics Piaget (1952). The participants in the study were excited to use the manipulatives for area. Students expressed that using these methods were new for them. Manipulative’s are methods used for modern day math. Multiple research studies support long-term use of manipulatives in mathematics. Educators found that students make gains in the following general areas area, multiplication, and division. (Hedden Picciotto 1998; Sebesta and Martin, 2004) The results of the action research relate to the findings of earlier math methods research. Krach studied problem solving and concluded that using manipulatives has been shown to help students reduce errors and increase their scores on tests that require them to solve problems (1998). Participants in the study increased scores on the area concept problem solving post-test.

Future Research

If someone were to complete the study again, they should conduct the study over a span of two to three weeks. By expanding the study, they will be able include more intervention hours and teach participants other methods to use manipulatives to solve math problems. It is recommended in the future that a third and fourth group be included in the study. The third group

would be able to use both color-tiles and geo-boards to learn area concepts. And the fourth group would not use manipulatives at all.

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