Using manipulatives to teach elementary mathematics

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ABSTRACT

The purpose of this paper is to explain the importance and benefits of math manipulatives. For decades, the National Council of Teachers of Mathematics has encouraged school districts nationwide to use manipulatives in mathematical instruction. The value of manipulatives has been recognized for many years, but some teachers are reluctant to use them in their lessons. Throughout this paper, a discussion of the positive results of several research studies that strongly suggest the use of manipulatives will be mentioned. The history and advancement of manipulatives with also be discussed. Defining manipulatives and explaining the correct way to use them will be highlighted in this paper.

Keywords: manipulatives, instructional methods, mathematics, instruction, NCTM, reluctant

INTRODUCTION

According to the Principles and Standards for School Mathematics, "the foundation for children's mathematical development is established in the early years" (Seefeldt & Wasik, 2006, p. 249). It is important for children to have a variety of materials to manipulate and the opportunity to sort, classify, weigh, stack and explore if they are to construct mathematical knowledge. "In order to have opportunities to learn math, children need firsthand experiences related to math, interaction with other children and adults concerning these experiences and time to reflect on the experiences" (Seefeldt & Wasik, 2006, p. 250). Educational research indicated that the most valuable learning occurs when students actively construct their own mathematical understanding, which is often accomplished through the use of manipulatives.

HISTORY OF MANIPULATIVES

Since ancient times, people of several different civilizations have used physical objects to help them solve everyday math problems. The ancient civilizations of Southwest Asia used counting boards, which were wooden or clay trays covered in a thin layer of sand. The counting board users would draw symbols in the sand to tally inventory or whatever else they may need to count. The ancient Romans created the first abacus based on counting board. The abacus was made of beans or stones which moved in grooves in sand or on tables of wood, stone, or metal. "The Chinese abacus, which came into use centuries later, may have been an adaptation of the Roman abacus" ("Research on the" n.d.). The Mayans and the Aztecs both had counting devices that were made of corn kernels strung on string or wires that were stretched across a wooden frame. The Incas also had their own counting tool, which was knotted strings called quipu ("Research on the", n.d.).

"The late 1800s saw the invention of the first true manipulative-maneuverable objects that appeal to several different senses and are specifically designed for teaching mathematical concepts" ("Research on the" n.d.). In 1837, German educator Friedrich Froebel introduced the world's first kindergarten. "He designed the educational play materials known as Froebel Gifts, or *Frobelgaben,* which included geometric building blocks and pattern activity blocks" ("Friedrich Froebel", 2009). Then in the early 1900s, Italian educator Maria Montessori continued with the idea that manipulatives are important to education. She designed several materials to help elementary students learn the basic ideas of math. "Since the 1900s, manipulatives have come to be considered essential in teaching mathematics at the elementary school level" ("Research on the," n.d.). In fact, the National Council of Teachers of Mathematics (NCTM) has recommended the use of manipulatives in teaching mathematical concepts at all grade levels.

MANIPULATIVES DEFINED

Manipulatives can come in a variety of forms and they are often defined as "physical objects that are used as teaching tools to engage students in the hands-on learning of mathematics" ("Using manipulatives," 2009). Manipulatives can be purchased at a store, brought from home, or teacher and student made. The manipulatives can range from dried beans and bottle caps to Unifix cubes and base-ten blocks. They are used to introduce, practice, or remediate a math concept. "A good manipulative bridges the gap between informal math and

formal math. To accomplish this objective, the manipulative must fit the developmental level of the child" (Smith, 2009, p. 20). Kindergarten children should have individual counters, whereas older students could use colored wooden rods that represent different numbers. The manipulative must fit the mathematical ability of the child or it is useless.

WAYS TO USE MANIPULATIVES

Manipulatives can be used in teaching a wide variety of topics in mathematics, including the objectives from the five NCTM standards: problem solving, communicating, reasoning, connections, and estimation. The materials should "foster children's concepts of numbers and operations, patterns, geometry, measurement, data analysis, problem solving, reasoning, connections, and representations" (Seefeldt & Wasik, 2006, p.93). Teachers could use counters, place-value mats, base-ten blocks, and fraction strips while teaching from the numbers and operations standard. The counters could be used to teach one-on-one correspondence, ordinal numbers, and basic addition and subtraction. The fraction strips could be used to add and subtract fractions or to show equivalent fractions. Pattern blocks, attribute blocks and scales could be used to assist students in the learning basic algebra. Student could use geoboards when trying to identify simple geometric shapes. They could also use geometric solid models when learning about spatial reasoning. Teachers could use standard and non-standard rulers and measuring cups to represent length or volume in measurement lessons. The students could also use tiles when trying to find the area or perimeter of an object. When it comes to data analysis and probability, students could use spinners to find the probability of landing on a designated area. They could also use number cases or dice to find the probability of rolling a certain number or combination of numbers ("Using manipulatives", 2009). The numbers of ways that manipulatives can be used are limitless. In fact, some schools use math manipulatives as a way to get parents involved. Stephen Currie, math specialist for grades Kindergarten through fourth grade at Poughkeespsie Day School in New York, created 'mathtubs' to pique math interest for both kids and their parents. Each Friday several students are selected to receive a mathtub, which are not due back until the next Wednesday. The mathtubs are filled with "math games and puzzles, two or more different kinds of manipulatives such as number cubes or tangrams and math challenges—questions which required no materials but creative brain power" (Currie, 2005, p. 52). Feedback from the parents was both positive and helpful. "In general, the parents appreciated the activities and were please to see their child engaged in mathematical thinking" (Currie, 2005, p. 53).

USING MANIPULATIVES CORRECTLY

Manipulatives can be extremely helpful young children, but they must be used correctly. Children must understand the mathematical concept being taught rather than simply moving the manipulatives around. Smith (2009) stated that there are probably as many wrong ways to teach with manipulatives as there are to teach without them. The math manipulatives should be appropriate for the students and chosen to meet the specific goals and objectives of the mathematical program. "The complexity of the materials provided will increase as children's thinking and understanding of mathematical concepts increase" (Seefeldt & Wasik, 2006, p. 93). It is also important for teachers to allow their students to have free time to play with the manipulatives. After the students have explored the manipulatives, "the materials cease to be

toys and assume their rightful place in the curriculum" (Smith, 2009, p.17). Carol Seefeldt and Barbara Wasik also think that teachers should provide children with opportunities to work with materials with open-ended objectives that have no specific preset goals. These opportunities allow the children the chance to explore their own questions and generate a variety of answers. "These experiences help children think about their world in alternative ways and help them understand that there are multiple ways to solve problems. Generating multiple solutions to problems in an essential strategy in mathematics" (Seefeldt & Wasik, 2006, p. 250).

RESEARCH AND BENEFITS OF MANIPULATIVES

The use of manipulatives is recommended by the NCTM because it is supported by both learning theory and educational research in the classroom. "Manipulatives help students learn by allowing them to move from concrete experiences to abstract reasoning" ("Research on the" n.d.). When students manipulate objects, they are taking the first steps toward understanding math processes and procedures. "The effective use of manipulatives can help students connect ideas and integrate their knowledge so that they gain a deep understanding of mathematical concepts" ("Research on the, " n.d.).

Over the past few decades, researchers have studied the use of manipulatives in several different grade levels and in several different countries. The majority of the studies indicate that mathematics achievement increases when manipulatives are put to good use. Many studies also suggest that manipulatives improve children's long-term and short-term retention of math. Cain-Caston's (1996) research indicates that using manipulatives helps improve the environment in math classrooms. When students work with manipulatives and then are given a chance to reflect on their experiences, not only is mathematical learning enhanced, but math anxiety is also greatly reduced. Kenneth Chang (2008) examined the work of research scientist Jennifer Kaminski and he found that children better understand math when they use concrete examples.

Puchner, Taylor, O'Donnell, and Fick (2008) conducted a case study which analyzed the use of manipulatives in math lessons developed and taught by four groups of elementary teachers. There four researchers decided to study the way teachers use the manipulatives rather than studying the outcomes of the students. "The study found that in three of four lessons studied manipulative use was turned into an end in and of itself rather than a tool, and that in the fourth lesson manipulative use hindered rather than helped the student learning" (Puchner, Taylor, O'Donnell, & Fick, 2008, n.p.). The researchers believe this occurred because of the "deeply embedded focus in U.S. mathematics teaching on the procedure and the product" (2008, n.p.). In a few of the lessons, the manipulative use became an exercise separated from the solving of the problem. In the second grade lesson, the students simply copied the teacher's example and never attached meaning to the manipulatives. The teacher's manipulative use and misuse provided the researchers with a focus for further study. The researchers also realized that "teachers need support making decisions regarding manipulative use, including when and how to use manipulatives to help them and their students think about mathematical ideas more closely" (Puchner, Taylor, O'Donnell, & Fick, 2008, n.p.). Catherine Kelly, a member of the Montana Council of Teachers of Mathematics, stated that "teachers need to know when, why, and how to use manipulatives effectively in the classroom as well as opportunities to observe, first-hand, the impact of allowing learning through exploration with concrete objects" (Kelly, 2006, p.188).

Dave Munger, author of *Researching Online*, reported the results of a study designed to describe the benefits of manipulatives. The sample consisted to two third-grade classes with

twenty-six students. A two-week geometry unit from the Silver Burdett textbook was administered in both classes. The experimental group teacher used mathematical manipulatives to teach the concepts presented in the unit, and the control group teacher used only drawings and diagrams to teach the concepts. "Analysis of covariance revealed that the experimental group using mathematical manipulatives scored significantly higher in mathematical achievement on the posttest scores than the control group" (Munger, 2007, n.p.).

Additional studies have shown that students who use "manipulatives in specific mathematical subjects are more likely to achieve success than students who don't have the opportunity to work with manipulatives" ("Research on the," n.d.). Some children need to use manipulatives to learn to count, while other students' understanding of place value increases with the use of manipulatives. Research also indicates that using manipulatives is especially useful for teaching low-achievers, students with learning disabilities, and English language learners.

CONCLUSION

Elementary teachers who use manipulatives to help teach math can positively affect student learning. Students at all levels and of all abilities can benefit from manipulatives. Mathematician, Seymour Papert, believes manipulatives are 'objects to think with'. "Incorporating manipulatives into mathematics lessons in meaningful ways helps students grasp concepts with greater ease, making teaching most effective" ("Research on the, " n.d.).

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