Using manipulative materials to increase student achievement in mathematics

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Abstract

This is an action research project to test a null hypothesis, which states that the use of manipulative materials within the context of mathematics instruction will not yield a significant in crease in student achievement. Based on the research, using manipulative materials should have a positive impact on student achievement. Allowing students to use tangible objects helps them to see the concept concretely instead of abstractly. Once a person sees something, it is more likely that they will remember or at least retain it for a longer period than if it was just told to them. This concept is the basis for the entire action research.

This action research was completed over the course of three days. The subjects that participated in the study were fifth grade students in a school in Detroit, Michigan. The students were required to take a pre-test and post-test on the addition and subtraction of fractions. First the students were given the Pre-test. Next the students were taught a lesson on adding and subtracting fractions using apples, oranges, and various other fruits as the as the denominators of our fractions. All students were given the

exact instructions on using fruits to understand the relationship of having like denominators before addition or subtraction of fractions takes place. All students were given the same pretest and posttest. As a result of my study I was able to reject the null hypothesis and state that the use of manipulative materials does yield a significant increase in student achievement with a 95% level of confidence.

Introduction

The use of manipulative materials in the mathematics classrooms has been widely discussed in the field of mathematics education. Teachers are striving to find new techniques that will help improve student achievement on standardized math tests and promote a more positive learning experience for students in math. Manipulative materials are essentially models that children utilize to learn how math works. Manipulative materials not only help children understand math, they also make math more pleasurable. Through the use of manipulative materials, the child develops a methodical understanding of concepts and computational skills. The fundamentals learned in the primary grades are building blocks for intermediate concepts. Active hands-on participation with mathematical experiences promotes the understanding of concepts that will benefit students throughout their lives. This takes the student from where they are in their own understanding and builds on their comprehension. Because children learn at their own pace, no limits are set with manipulative materials. They can continue to explore, experiment, and observe math in a real world context, which in turn will create a more concrete understanding.

Chapter I:

Problem Statement

Students within the general contextual setting of my classroom continue to underachieve in mathematics. The under achievement is attributed to students not fundamentally understanding or retaining mathematical concepts they were previously introduce to in earlier grades. With the state mandated tests and the no child left behind legislation dictating student achievement, there is an even greater need to find ways to assist students in owning these fundamental concepts.

Elements of the Problem

Mathematics has been traditionally viewed as a culture where success is based upon your parents understanding of math. I see all to often or hear discouraging remarks about well I wasn’t good in math either, you know math is their weakest subject or I don’t even know how to help them understand. As an educator, a conscious effort by me is being made to change this view of mathematics to an orientation that focuses on making mathematics accessible and enjoyable for all children and adults as well. Reform efforts address topics such as the need for relevance by

virtue of providing real-life applications, collection and organization of data, and problem solving as opposed to rote memorization of procedures. In addition, the Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989), prepared by the National Council of Teachers of Mathematics, while not directly addressing cultural diversity issues, advocates instructional practices that include the use of manipulative materials, cooperative work, communication of mathematical ideas in everyday language, and writing about mathematics. Jones (1986) concludes that manipulative materials should be incorporated into the curriculum with the goal of helping the students understand mathematics.

Purpose of Study

The purpose of this action research is to examine the effects that the use of manipulative materials have on student achievement in mathematics. As a result, this researcher will conduct a study to determine whether the use of manipulative materials in mathematics yields a statistically significant increase in student achievement.

Definition of Terms

Math Manipulative – Rust (1999) defines manipulative as any hands-on object that the student can physically move in order to discover the solution to the problem.

Mathematics – Hinzman (1996) defines mathematics as the science of numbers and sets and their general operations, relations and combinations and of space configurations and their structure, measurement and transformations.

Hands-on activities- activities using objects that appeal to several senses, [which] can be touched, handled or moved.

Null Hypothesis

The following null hypothesis was tested using a pre-test and post-test on understanding how to add and subtract fractions:

1. The use of math manipulative materials does not create a significant increase in students' mathematic test scores.

Chapter II:

Literature Review

The idea that physical objects playing an important role in the learning process, is an idea that has been lurking on the surface of education for an extended period of time. Traditionally formal education focused almost exclusively on lectures and recitations. One of the first advocates for "hands-on learning" was the Swiss educator Johann Heinrich Pestalozzi (1746-1827). Pestalozzi asserted that students need to learn through their senses and through physical activity, arguing for "things before words, concrete before abstract" Using concrete materials to teach mathematics is a long-established pedagogical strategy (Brownell, 1928). Based on theories claiming that children need concrete referents to develop abstract mathematics concepts (Piaget, 1966), and supported by research showing qualified advantages from using concrete materials (Sowell, 1989), educators have advocated using manipulative for instruction (Burns, 1996). Other researchers and educators have argued that these materials are not automatically helpful (Ball, 1992; Resnick & Omanson, 1987). In general, research on manipulative has focused on whether they were generally good or bad for instruction. I doubt that hands-on materials are beneficial

or harmful for learning mathematics overall. There are multiple perspectives concerning how manipulative help students learn mathematics, though little evidence firmly supporting any one view (Chao et al., 2000). One idea is that exposure to multiple representations leads to better understanding of underlying mathematical principles (Moreno & Mayer, 1999). This view implies that using many different manipulative to teach a mathematics concept is the best instructional strategy.

Clements (1999) states students who use manipulative materials in their mathematics classes usually outperform those who do not, although the benefits may be slight. This benefit holds across grade level, ability level, and topic, given that use of a manipulative "makes sense" for that topic. Manipulative use also increases scores on retention and problem solving tests. Attitudes toward mathematics are improved when students have instruction with concrete materials provided by teachers knowledgeable about their use.

However, manipulative materials do not guarantee success. One study showed that a class not using manipulative materials outperformed a class using manipulative materials on a test of transfer. In this

study, all teachers emphasized learning with understanding. In contrast, students sometimes learn to use manipulative materials only in a rote manner. Students may require concrete materials to build meaning initially, but they must reflect on their actions. They need teachers who can reflect on their students' representations for mathematical ideas and help them develop increasing sophisticated and mathematical representations. "Although kinesthetic experience can enhance perception and thinking, understanding does not travel through the fingertips and up the arm." In order for mathematics classes to become more exciting and entertaining for the students, teachers need to involve students physically in hands-on learning experiences, and this can be accomplished using manipulative materials. McClung (1998) states that using manipulative aids and devices makes the classroom a more interesting and exciting place for both teachers and students.

Chapter III:

Methodology

Research Design

This researcher will study a fifth grade class. A pre-test will be given on the first day to determine each prior knowledge and student levels. This will allow the researcher to determine a true score in the group post-test. On day two the researcher will give instructions and a post-test will be given on the third day.

Subjects

The subject site is Detroit Edison Public School Academy in Detroit, Michigan. The study consisted of 30-33 5th grade students. This researcher will conduct a pre-test, give instruction and then conduct a post-test. This researcher understands that the limitations of the study findings cannot be used to project outcomes of other studies because findings may differ due to the restrictions of the sampling.

Control Method

The researcher gave a lesson on the understanding of fractions and the students listened. The researcher sat in the front of the class using an overhead projector to demonstrate the use of fractions. Students would write the examples in their notebooks. For instance, if the

researcher were demonstrating ¾ + ½, he would draw a square on the projector and break it into four pieces shading only three of the four, and the students would follow along then he would demonstrate how the fourths are not the same as halves so you cant just add them together which will spark their curiosity. Several examples were given and then the students were given a worksheet on fractions to practice.

Variables

For the purpose of this study there will be two variables used. The independent variable is the use of manipulative material and the dependent variable is the change in academic achievement. The group will receive instruction on how to add and subtract fractions and they will also be given Manipulative Materials to use. The lessons will be taught by the researcher so there won't be any influence from outside sources.

Methods of Data Collection

The data will be generated using a pre-test and post-test on adding and subtracting fractions. The pre-test and the post-test will be similar. As in most studies, the post-test will not be identical to the pre-test. It is assumed that students will perform better on a test the second time it is taken.

Data Analysis Procedures

A one-tailed paired data T-test at the .05 significance level will be used to analyze the data collected from both the pre-test and the post-test after the data had been generated. A significant change that is equal to or lesser than the level .05 would indicate that there was reason to reject the null hypothesis with at least a 95% confidence level.

Timeline

This study will be conducted over a three day time period during 1st hour math block. Students will be given a pre-test on the first day. On the second day the researcher will give instruction and on the third day the post-test will be given.

Chapter IV:

Comparison of Pre-test and Post-test

There were 28 students who were involved in this action research. These students received no instruction on how to add and subtract fractions prior to them taking a pre-test on the topic. The next day the students were taught a lesson on how to add and subtract fraction. The post-test was given on the third day of this research which had its similarities to the pre-test but not identical. The tests were both equal in content and the material it contained. Students were given as much time as needed to take both test during the class period. Both tests were scored based on the number of correct answers attained with 100% being a perfect score. The change between the pre-test and post-test scores, were calculated for this group of students to determine the improvement factor. The mean score for change of the group of test subjects was 47.143. The standard deviation of change was calculated to be 20.7. The critical t was 1.703. The level of significance for the test subjects was calculated to be .05. The null hypotheses stated that the use of math manipulative materials does not create a significant increase in students' mathematic test scores at a .05 level of significance. With the significance being .05 the researcher has the ability to

accept or reject the null hypothesis. As a result of the t-test being 2.009 this researcher rejects the null hypothesis, with a 95% confidence level.

Student Test Average Scores

Group	Number	Mean	T-Score
Pre-Test	28	8.214	
Post-Test	28	55.357	
T-Score			2.009

Chapter V:

Summary

This researcher conducted an action research project with one-fifth grade mathematic class on addition and subtraction of fractions. The study took place over a three-day period of time. The class was given a pre-test, on the first day of research, to measure their knowledge of adding and subtracting fraction. The following day students were presented with a lesson on adding and subtracting fraction with the inclusion of manipulative materials. On the third day of the research project the students were given a post-test to measure the growth of knowledge that took place due to the lesson on adding and subtracting fraction with the use of manipulative material.

Conclusion

Due to the adding and subtracting fraction instruction in conjunction with manipulative material, the test subjects increased their knowledge, showed more interest and enjoyed the lesson. The students not only learned but also had the ability to construct their own knowledge and develop a fundamental understanding. Upon observation, students grew more interested and confident in their math skills. This form of knowledge ensures that students will take more ownership in their education. Therefore, the null

hypothesis can be rejected with a 95% confidence level. Which proves that the use of manipulative materials has a profound effect on students' academic achievement.

Recommendations

It is the recommendation of this researcher, that instructors use manipulative material within the scope of mathematics instruction when the situation makes it possible. Make sure when you give instruction you allow students the opportunity to work on concepts without the teacher's involvement. Students who explore concepts and succeed in their exploration of the unknown are more likely to retain the information.

Appendix A

Pre-Test and Post-Test Scores/Changes/Averages

Test Group Pre-Test Raw Scores	Test Group Post-Test Raw Scores	Test Group Change Raw Scores
0%	50%	50%
10%	70%	60%
20%	50%	30%
0%	60%	60%
10%	80%	70%
0%	50%	50%
0%	70%	70%
0%	40%	40%
20%	40%	20%
0%	70%	70%
10%	30%	20%
0%	10%	10%
0%	90%	90%
0%	40%	40%
10%	50%	40%
30%	90%	60%
0%	40%	40%
40%	100%	60%
10%	10%	0%

20%	90%	70%
30%	80%	50%
0%	60%	60%
0%	20%	20%
0%	40%	40%
10%	40%	30%
0%	60%	60%
10%	50%	40%
0%	70%	70%
Average Pre-test Score 8%	Average Post-test Score 55%	Change In The Averages 47%

References

Ball, D. L. (1992). Magical hopes: Manipulative and the reform of math education. *American Educator: The Professional Journal of the American Federation of Teachers, 16*(2), 14-18.

Brownell, William A. (1928). *The development of children's number ideas in the primary grades*. Chicago, IL: The University of Chicago Press.

Burns, M. (1996). How to make the most of math manipulative. *Instructor, 105*(7), 45-51.

Cary, M. & Carlson, R. A. (1999). External support and the development of problem-solving routines. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*(4), 1053-1070.

Chao, S., Stigler, J. W., & Woodward, J. A. (2000). The effects of physical materials on kindergartners' learning of number concepts. *Cognition and Instruction, 18*(3), 285-316.

Clements, D. H. (1999). 'Concrete' manipulative, concrete ideas. Contemporary Issues in Early Childhood, 1(1), 45-60.

Moreno, R. & Mayer, R. E. (1999). Multimedia-supported metaphors for meaning making in mathematics. *Cognition and Instruction, 17*(3), 215-248.

Piaget, J. (1966). *Psychology of intelligence*. Totowa, NJ: Littlefield, Adams & Co.

Resnick, L. B., & Omanson, S. F. (1987). Learning to understand arithmetic. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 3, pp. 41-95). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Sowell, E. (1989). Effects of manipulative materials in mathematics instruction. *Journal for Research in Mathematics Education, 20*, 498-505.

Uttal, D. H., Scudder, K. V., & DeLoache, J. S. (1997). Manipulative as symbols: A new perspective on the use of concrete objects to teach mathematics. *Journal of Applied Developmental Psychology, 18*, 37-54.