

# Constructed Learning in Elementary Mathematics

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**Abstract:** Math manipulatives are an exciting way to interest elementary school students. Which designs are most useful? In what way(s) do manipulatives affect the learning process? In my Undergraduate Research Fellowship, I explored varying designs of math manipulatives and which could be most effective in teaching elementary school students. I then designed an affordable and easily manufactured manipulative. This paper details research with elementary school students in some of the ways the manipulatives were used to teach lessons on counting, tens places, and money skills.

## Keywords

elementary mathematics, place value, 3D printer, manipulatives, tens places, money skills, affordable manipulatives

## Introduction

As an elementary special education major, I have always been interested in how students work with new materials and how they follow instructions. I decided to research math manipulatives and how they benefit students and student's responses to them. With this information math manipulatives were created with a 3D printer taking into account my findings. Math manipulatives are a great visual tool that heavily influence and help develop student's skills. They are so important to children's learning that they are utilized across the world which is part of the reason why it is interesting and important to research.

## Literature Review

I researched how students tend to respond to instructions based on their grade level. Boggan, Whitmire, and Harper stated "manipulatives can be extremely helpful [to] young children, but they must be used correctly. Children must understand the mathematical concept being taught rather than simply moving the manipulatives around" (Boggan, Harper, and Whitmire, 2019). When using math manipulatives in the classroom it is extremely important to explain the lesson and how to do it. Jim Wright found that students (specifically students that are not identified as gifted) can struggle with basic skills and usage of cognitive strategies. Students can lack the capability of higher-level thinking that is needed for success in various content areas. These factors can make it very difficult for students to be able to follow directions. This is especially due to the fact that they have difficulties obtaining information (Wright, 2008). Although this can happen many students at a young age can follow instructions, but it helps if the instruction is modified to their specific needs. Capriola found that many gifted students struggle to follow directions because they already know a way to do something or they can figure out a way on their own. It is also common for gifted students to get bored by work and to lose focus or not want to do work that they find easy (Capriola, 2019). In my experience, I have viewed these patterns among gifted students, but I had not been able to conduct research. We thought it would be interesting to analyze how students responded to new materials and specific instruction.

## Research

After analyzing math manipulatives (Saafir, 2019; Lee, 2019; Boggan 2010) for elementary students, I developed a 3D printed design to teach students a variety of math lessons. Many factors were taken into account when creating the design, such as color, size, and material. Based on the research different colors that are engaging for students were picked (Ceri, 2013).

Group 1 subjects consisted of first graders (N=30). The lessons were modified to be specified to the first-grade curriculum. (3) Three different lesson plans were designed around money. The lessons are adding and subtracting money, identifying place values, and exchanging currencies between countries. For the first-grade class the problems were created to mostly have numbers below twenty to follow the first-grade curriculum. First grade students should be able to *use properties of addition to add whole numbers to solve addition and subtraction problems within 20*. A few problems included larger numbers as challenges. We went into the first-grade classroom three different times and tested the three different lessons using my math manipulatives. The lessons were recorded in order to analyze the footage and collect data. It was evident that math manipulatives were not a focus point in this classroom. The room did not have a lot of math posters up for the students to use. We believe this reflected in the students' work.

The first graders (N=30) were taught three different lessons across the course of (3) three different days. The first day students were given five problems that dealt with adding and subtracting money. They were given about (7) seven to ten minutes to do these problems. To introduce the lesson, a script was followed that stated, "We are going to do an activity with you where you will do five problems with adding and subtracting money. There are math manipulatives to help you work through the problems. A key denoting values to each element was posted for students. Try to get as many problems done as you can. If you have any questions, please ask them." The second day involved identifying place values. The students were given five questions and had about seven to ten minutes to solve them. The same script was followed, but it introduced solving place value problems. On the third day the students were read a few pages from a book about monsters going to the market (Bingham, 2018). The pages were printed off and the students answered a few addition and subtraction problems from it. Then the students worked through five problems where they converted United States currency to Mexican currency. The same script was used to introduce this, but it explained what the U.S. currency was equal to in Mexican currency.

We also worked with a Kindergarten class (N=20). The lessons were modified to fit their curriculum by using numbers ten and below. Kindergarten students should be able to *understand addition as putting together and subtraction as taking from*. This work took place in the spring semester during February and March, so the student's skills should have been proficient at this point. A few problems had larger numbers to challenge the students and to see how they used the manipulatives to problem solve. These lessons were also recorded in order to analyze how the students used the math manipulatives and how they followed the instructions given. The teacher had math stations set up with various math manipulatives. It was evident that the teacher stressed the importance of math in their classroom. There were math posters and number lines hung up on the walls that students could look at to help them with their work. This importance that was put on math was also reflected in the student's work.

The Kindergarten class was given three math lessons over the course of two days. The same script was used to introduce the first lesson of adding and subtracting. The students were given about ten minutes to solve five different problems. On the second day the place values lesson and the exchange of currencies lesson took place. The same script was used for these days, but it made it clear that they were two different lessons. They were given about ten to fifteen minutes to solve ten problems (five for each lesson.)

## Results

From the research conducted there were a variety of interesting findings. Many common themes appeared throughout of how the students utilized the math manipulatives and how they followed instruction. The research showed that students followed instructions differently based on their cognitive level. Many students who were identified as gifted were able to follow instructions; however, they typically did not use the math manipulatives. This could be because they already knew how to do the problems, so they did not need the math manipulatives to

help them. This was evident because the students that were identified as gifted would get straight to work and solve the problems quicker than other students. Many students would count on their fingers or draw pictures to figure out the problem. Many students who used the math manipulatives did not acknowledge the key and they would count by ones with the manipulatives. If how to use the math manipulatives was explained the gifted students would understand and follow instructions, but they were not required to use them so many chose not to. The groups of students that were not identified as gifted tended to rely on more instruction to solve the problems. When the students were instructed on what to do, they would typically be able to solve the problems on their own after doing one or two problems with guided instruction. Students were helped through the first problem by explaining how the math manipulatives work. How to do the problem using the math manipulatives was explained, but questions were asked to make them an active learner. Many students that were not identified as gifted would ask more questions than gifted students. These themes showed that although the students appeared to be unfamiliar with the math manipulatives, they were able to adapt and use them to their benefit.

## Scholarly Significance

Although many different themes were discovered during the research there is a lot more that can be researched. We plan to make more math lessons involving my math manipulatives to conduct research with higher grade levels in the future. It would be helpful to see how second and third graders respond to the math manipulatives. We hope to research how a higher education affects their response to instructions and new material. It will be interesting to see if it is more difficult for students to adapt to new materials at a higher grade level. It will also be interesting to see if they are better at following instructions since they have been in school longer. The completed research data will be compared to future data to find these results. It will also be interesting to find any other patterns of students at this grade level.

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