European Journal of Humanities and Educational Advancements (EJHEA)
Available Online at: https://www.scholarzest.com
Vol. 4 No. 2, February, 2023
ISSN: 2660-5589

HOMEMADE MANIPULATIVE MATERIALS FOR TEACHING GRADE IV MATHEMATICS

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Article history:
Received: December 6th 2022
Accepted: January 4th 2023
Published: February 6th 2023

Abstract:
Manipulative materials can create mental representations of abstract mathematical concepts and operations. It engages the learners and increases their interest in mathematics. The researchers believe that using homemade manipulative materials would help increase the mathematics performance of Grade IV pupils in a public elementary school situated on an islet of Bantayan Island on the northern tip of Cebu, Philippines. The study utilized a quasi-experimental design and a teacher-made test to gather the data. The study determined the pretest and posttest performances of the control and experimental groups. The researchers subjected the data to a series of comparisons to establish the effectiveness of the homemade manipulative materials in teaching Grade IV mathematics. As revealed in the study, using manipulative materials for pupils in elementary mathematics is a practical activity to develop the pupils' cognitive skills. Learning is assimilated faster with real-life manipulative materials pupils can touch or concretize. In an islet or any place with limited access to commercial manipulative materials for learning mathematical concepts, homemade manipulative materials, such as bottle caps, pebbles, and shells abundant in the locality, are excellent substitutes for learning mathematics. Hence, using homemade manipulative materials in teaching mathematics to young learners is highly recommended to save costs and recycle whatever materials are found in the locality. Such innovativeness on the part of the teachers would make them successful in imparting learnings to their pupils not only about mathematical concepts but also on the value of conservation and recycling materials.

Keywords: Mathematics teaching, math manipulatives, quasi-experimental, Cebu Province, Philippines

1. INTRODUCTION

Life would not be possible without mathematics. One must have a solid foundation in mathematics to keep up with changes in today's environment. People run into circumstances where math ability is required every day (Kenedi et al., 2019). Students must master abstract concepts if they are to succeed in mathematics. Elementary school teachers frequently use math manipulatives to help pupils connect abstract concepts they are learning to prior knowledge and portray those concepts in concrete terms. However, in many modern classrooms, teachers and students also employ visual and virtual manipulatives. Traditionally, teachers and students used concrete manipulatives (Bondurant, 2015). For students to think and reason more deeply, manipulatives are crucial. Teachers can provide pupils with a more meaningful experience by using manipulatives since they give them a physical shape for which they can later perceive the relevance (Simon, 2022). With the help of manipulatives, students can create mental representations of abstract mathematical concepts and operations. They can also communicate these representations using a common language with the teacher and other students. Manipulatives offer the additional benefit of engaging pupils and boosting interest in and pleasure of mathematics and their capacity to directly support the cognitive process. Students who are given a chance to utilize manipulative materials have a greater interest in learning mathematics. Long-term mathematical interest leads to improved mathematical skills (Post, 1981).

In an islet situated at the northern tip of Cebu, Philippines, the researchers have found that Grade 4 pupils struggle to understand mathematical concepts. As observed, students become frustrated with their mathematics lessons, resulting in low test scores and difficulty completing homework, and they get bored quickly when exposed to mathematical problems. The researchers believe that using manipulative materials in teaching mathematics would help increase this group of pupils' performance in mathematics. A literature search reveals that there are studies conducted about the use of commercial manipulatives in teaching mathematics (Boggan et al., 2010; Dorward & Heal, 1999; Moyer, 2001; Puchner et al., 2008) and some studies about homemade manipulatives (Sanderson, 2014; Stallings-Roberts, 1994). However, the researchers cannot find a study using homemade manipulatives to teach Grade 4 mathematics using control and experimental groups. Moreover, the researchers cannot find a study that suits their intention to analyze the effectiveness of using homemade manipulatives in teaching mathematics among Grade 4 pupils in a remote islet with limited access to technology and commercially sold manipulatives. Hence, the researchers conducted this study.

2. FRAMEWORK OF THE STUDY

First, the researchers anchored this study on the dual coding theory by Paivio (1991), which seeks to balance the importance of verbal and nonverbal processing. The theory claims that human cognition is distinctive because it has evolved into a specialty for simultaneously coping with language and nonverbal things and events. Accordingly, there are two cognitive subsystems, one with a focus on dealing with language and the other with a focus on representing and processing nonverbal objects and events (Clark & Paivio, 1991). Second, the study holds on Fleming's VARK learning styles, which identify four basic learning styles: visual, auditory, reading/writing, and kinesthetic. According to this theory, students learn best when instruction and extracurricular activities fit their individual learning preferences, strengths, and learning styles (Prithishkumar & Michael, 2014). Finally, this study also holds to the theory of multiple intelligences by Gardner (1987), which contends that there are eight unique types of intelligence: visual-spatial, verbal-linguistic, musical-rhythmic, logical-mathematical, interpersonal, intrapersonal, naturalistic, and bodily-kinesthetic. This theory contends that humans learn in several ways, in contrast to existing theories of learning capacities. According to this theory, teachers can modify their teaching methods and advise students on specific career options if they are aware of the potential types of intelligence they may possess.

3. OBJECTIVES OF THE STUDY

The study determined the effectiveness of homemade manipulative materials in teaching grade four Mathematics in Botigues Integrated School, Bantayan, Cebu, Philippines during the academic year 2017-2018. Specifically, the study determined the: 1) pretest performances of the control and experimental groups, 2) posttest performances of the control and experimental groups, 3) significance of the difference between the pretest performances of the control and the experimental groups; 4) significance of the differences between the pretest and posttest performances of each group of pupils, and 5) significance of the difference between the pretest and posttest performances of the control and experimental group.

4. MATERIALS AND METHODS

The researchers of this study utilized the quasi-experimental method of research, precisely the non-equivalent, pretest-posttest approach. The researcher conducted the study in Botigues Integrated School, located in an islet still part of the Municipality of Bantayan, an island at the northern tip of Cebu Province in the central part of the Philippines, which lasted for two months. During the study, the school has 550 students, 20 teachers, and the school head. The study participants were 60 Grade IV pupils during the first quarter of School Year 2017-2018. The participants were divided into two groups based on gender and final grade in Grade III Mathematics. The first set of pupils was the control group and was taught mathematical concepts using the pure lecture and chalkboard approaches. The second set of pupils was the experimental group which taught math concepts using homemade manipulative materials. Pretest and posttest using the teacher-made test were conducted to measure the pupils' performances before and after the experiment. Other math teachers validated the teacher-made test used in the pretest and posttest to check the appropriateness of the content and construction. After several revisions, the teacher-made test was pilot tested to determine its internal consistency. The pilot testing yielded a Cronbach's alpha coefficient of 0.8208, above the passing threshold of 0.7000. The scores of the pretest and posttest were categorized using the following score ranges and descriptions: 31-40 (very satisfactory), 21-30 (satisfactory), 11-20 (less satisfactory, and 0-10 (unsatisfactory).

The teacher-made test covers the first quarter topic of Grade IV Mathematics: numbers and number sense, multiplication, and division of whole numbers. The competencies covered were identifying the place value of a number (manipulative materials used were bottle caps); reading and writing numbers in words and in symbols (manipulative materials used were pebbles); rounding numbers to the nearest thousands and ten thousand (manipulative materials used were shells); comparing numbers (manipulative materials used were shells); ordering numbers up to 100,000 (manipulative materials used were pebbles); multiplying numbers up to three digits by numbers up to two digits without regrouping (manipulative materials used were bottle caps, pebbles and shells); multiplying numbers up to three digits with regrouping (manipulative materials used were bottled caps, pebbles, and shells); solving routine and non-routine word problems involving multiplication of whole numbers including money (manipulative materials used were shells); and solving multi-step routine and non-routine word problem involving division (manipulative materials used were shells). Frequency count and percentage were used by the researchers in summarizing and analyzing the pretest and posttest performances of the participants. Next, the t-test for independent samples was used to determine the significance of the difference between the pretest scores of the control and experimental groups. Furthermore, the t-test for correlated samples was used to determine the significance of the difference between the pretest and posttest scores for each group of participants. Lastly, the t-test for independent samples was used to determine the significance of the difference between the posttest scores of the control and experimental groups.

5. RESULTS AND DISCUSSION

Table 1

Pretest Scores of the Control and Experimental Groups

		Control Group		Experimental Group	
Score Ranges	Description	Frequency	%	Frequency	%
31 - 40	Very Satisfactory	0	0.00	0	0.00
21 - 30	Satisfactory	3	10.00	2	6.67
11 - 20	Less Satisfactory	19	63.33	15	50.00
1 - 10	Unsatisfactory	8	26.67	13	43.33
	Total:	30	100.00	30	100.00
	Mean:	16.40		14.37	
	SD:	5.45		6.32	

Test of Difference: t-stat = 2.00; p-value = 0.19; not significant at 0.05

Table 1 showed that 63.33% of the pupils in the control group got a score between 11 and 20 and described it as less satisfactory, while 26.67% got a score between 0 and 10 and described it as unsatisfactory. The remaining 10% of the pupils in the control group scored between 21 and 30 and were described as a satisfactory performance. In the experimental group, 50% of the pupils scored between 11 and 20. Their performances are less satisfactory. 43.33% of this group got a score between 1 and 10, which was described as unsatisfactory. The remaining 6.67% got a score between 21 and 30 and described it as a satisfactory performance. The data revealed that most of the control and experimental group students showed less satisfactory performance in the pretest. The test of the difference between the pretest scores of the control and experimental groups reveals that there is no significant difference between the pretest scores of the pupils in the control and experimental groups (p-value = 0.19). The finding implies no significant difference in mathematical ability between the control and experimental groups of pupils. Hence, the researchers can proceed with the experiment without the doubt that one group is better than the other. According to Gribbons and Herman (2019), the non-equivalent group pretest-posttest design partially eliminates a significant limitation of the non-equivalent group posttest-only design. At the start of the study, the researcher empirically assesses the differences between the two groups. Therefore, if the researchers find that one group performs better than the other on the posttest, they can rule out initial differences if the groups were, in fact, similar on the pretest.

Table 2

Posttest Scores of the Control and Experimental Groups

		Control Group		Experimental Group	
Score Ranges	Description	Frequency	%	Frequency	%
31 - 40	Very Satisfactory	6	20.00	24	80.00
21 - 30	Satisfactory	21	70.00	4	13.33
11 - 20	Less Satisfactory	0	0.00	2	6.67
1 - 10	Unsatisfactory	3	10.00	0	0.00
	Total:	30	100.00	30	100.00
	Mean:	25.37		31.70	
	SD:	6.81		6.23	

Table 2 revealed that 70% of the pupils in the control group got a score between 21 and 30, which was described as satisfactory. The 10% of the pupils of the same group got a score between 1 and 10 and were described as an unsatisfactory performance. However, 20% of pupils in the control group scored between 31 and 40 and were described as having very satisfactory performance. In the experimental group, 80% of the pupils scored between 31 and 40 and were described as having very satisfactory performance. Meanwhile, 13.33% of the pupils in the experimental group got a score between 21 and 30 and described a satisfactory performance. The remaining 6.67%

got a score between 11 and 20 and were described as having less satisfactory performance. The data showed an increase in the pupils' performances in the control and experimental groups in their posttest. However, more students showed very satisfactory performances in the experimental group than in the control group. The finding implies that the pupils in the experimental group are performing better than their counterparts in the control group based on their posttest scores. To check if there were significant increases in the posttest scores of the pupils, the researchers conducted tests of the difference between the pretest and posttest scores of each group of pupils. The result is shown in Table 3.

Table 3

Difference Between the Pretest and Posttest Scores of the Control and Experimental Groups

Group	Mean Gain	t-stat	p-Value	Decision on Ho	Interpretation
Control	8.97	2.05	0.00	Reject Ho	Significantly Different
Experimental	17.33	2.05	0.00	Reject Ho	Significantly Different

Table 3 shows a significant difference (p-value = 0.00) between the pretest and posttest scores of the pupils in the control group. Based on the mean gain score (8.97), the data shows a significant increase in the posttest scores of the pupils in the control group compared to their pretest scores. There is also a significant difference (p-value = 0.00) between the pretest and posttest scores of the pupils in the experimental group. Based on the mean gain score (17.33), the data shows that there is also a significant increase in the posttest scores of pupils in the experimental group as compared to their pretest scores. It means that both approaches given to each group of pupils are effective. However, it can be gleaned that there is a more significant increase in the posttest scores among the pupils in the experimental group, which were taught using manipulative materials. To validate this finding, the researchers conducted a test of the difference between the posttest scores of the control and experimental groups. The result is shown in Table 4.

Table 4

Difference Between the Posttest Scores of the Control and Experimental Groups

Group	Mean	t-stat	p-Value	Decision on Ho	Interpretation
Control	25.37	2.00	0.00	Reject Ho	Significantly Different
Experimental	31.70				

Table 4 shows a significant difference (p-value = 0.00) between the posttest scores of the pupils in the control and experimental groups. As indicated, the experimental group's mean score (31.70) is significantly higher than the control group's mean score (25.37). The findings indicated that pupils in the experimental group did better in the posttest, which was exposed to manipulative materials in teaching the lesson. This observation is similar to the study's outcome by Allen (2007) when she said the students in her study have improved their level of achievement, increased their understanding, and gained a positive attitude toward a mathematical concept that they previously struggled with using a manipulative. The finding is also supported by Suh and Moyer-Packenham (2007) when they said that students do much better on tests when given dual codes of visual and symbolic representations. Building mental images for symbolic and numeric representations is essential for students to improve their mathematical understanding. They suggested that dual-coded representations in virtual manipulatives environments and models may be more effective in teaching different cognitive processes, especially concepts where stored and captured procedures can develop algorithmic thinking. Clark and Paivio (1991) states that dual coding allows equal verbal and non-verbal processing weights.

6. CONCLUSIONS

Using manipulative materials for pupils in elementary mathematics is a practical activity to develop the pupil's cognitive skills. Learning is assimilated faster with real-life manipulative materials pupils can touch or concretize. In an islet or any place with limited access to commercial manipulative materials for learning mathematical concepts, homemade manipulative materials, such as bottle caps, pebbles, and shells abundant in the locality, are excellent substitutes for learning mathematics. Post (1981) stated that using manipulative materials in teaching mathematics allows the learners to construct their cognitive models for abstract mathematical ideas and processes and provide a common language to communicate these models to the teacher and co-learners. Moreover, manipulative materials aid directly in the cognitive process and can engage the learners and increase both interest in and enjoyment of mathematics. Long-term interest in mathematics translates to increased mathematical ability. The findings validate the dual coding theory of Paivio (1991) which seeks to balance the importance of verbal and nonverbal processing. In this study, using homemade manipulative materials in teaching mathematics to young learners is highly recommended to save costs and recycle whatever materials are found in the locality. Likewise, the study's findings corroborate Fleming's VARK learning styles and Gardner's theory of multiple intelligences since using homemade manipulative materials promoted active engagement among the pupils in learning various concepts in mathematics. Furthermore, the innovativeness on the part of the teachers in utilizing whatever available teaching materials would make them successful in imparting knowledge to their pupils not only about mathematical concepts but also the values of conservation and recycling materials.

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