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## RESEARCH ARTICLE

### The Use of Manipulatives in Teaching Grade 8 Mathematics

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## ABSTRACT

Mathematics is often perceived as a difficult subject due to its abstract nature, making it challenging for students to grasp key concepts, especially at the Junior High School level. This study investigated the effectiveness of manipulatives in teaching Grade 8 mathematics to address low academic performance among students. It aimed to determine the students' performance before and after the use of manipulatives, compare the results with those taught through traditional methods, and assess the significance of the difference between their scores. As an output, the study proposes the integration of manipulative-based instruction to improve conceptual understanding and enhance overall student achievement in mathematics. This employed a quasi-experimental quantitative design and had 60 grade 8 students of the University of Cebu at Pardo and Talisay. The research involved two groups: an experimental group taught with manipulatives and a control group taught using traditional methods. Pretest and posttest scores were analyzed using the mean, paired, and independent t-tests to determine performance differences within and between groups. Findings revealed that while both groups showed improvement from pretest to posttest, the experimental group exhibited significantly higher gains in mathematical achievement. The posttest scores of students who were taught using manipulatives were notably higher compared to those in the control group, affirming the positive impact of hands-on materials in facilitating conceptual understanding. The study recommends integrating manipulatives in regular instruction to foster student engagement, improve comprehension, and support differentiated learning in mathematics classrooms. Additionally, school administrators are encouraged to provide training and sufficient resources to support the effective use of manipulatives in classroom instruction.

## KEYWORDS

*Manipulatives, Grade 8 Mathematics, Quasi-experimental, Cebu City, Philippines.*

## ARTICLE INFORMATION

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## 1. Introduction

In the 21st century, the demands of a fast-changing world where critical thinking, problem-solving, and teamwork are essential skills for the success of education. As a fundamental discipline, mathematics frequently presents learners with abstract notions that challenge them. However, traditional mathematics teaching methods sometimes fail to completely engage pupils, especially when dealing with abstract and difficult subjects. Integrating mathematical manipulatives in education has been widely recognized as a transformative approach to improve student understanding and engagement.

On a global scale, manipulatives are useful in increasing pupils' conceptual comprehension and problem-solving skills. Piaget & Inhelder (2014) stressed that learners build knowledge via hands-on experiences, a principle that underpins the usage of manipulatives. Similarly, Bruner (1974) advocated for the enactive learning style, in which concrete experiences come before abstract thinking. It examines potential risks and advises instructors to use arithmetic manipulatives in their classrooms.

In the Philippines, manipulatives play a crucial role in education, particularly in subjects such as mathematics. Morales (2022) found that using manipulatives in algebra instruction with high school pupils led to considerable improvement in problem-solving abilities and conceptual knowledge. Manipulatives are explored specifically in primary education and their influence on student experiences and outcomes in mathematics (Rosli et al., 2015)

In Cebu, manipulatives serve as a uniting medium for instruction, where cultural and linguistic diversity fosters unique educational challenges. (Gravito et al., 2023) focused on creating and using locally available, low-cost manipulatives (such as paper, cardboard, and recycled materials) to teach mathematics concepts to Grade IV pupils in a public elementary school. Few local studies have focused on students' lived experiences when using manipulatives. The experience is crucial for developing instructional strategies relevant to Cebuano learners, whose learning environments may differ dramatically from those in more urbanized settings.

Although numerous studies have examined into the use of manipulatives in mathematics education, most of the evidence is qualitative or focused on elementary grades, limiting application and evidence-based decision making for secondary classrooms (Baruiz & Ed.D, 2023), but there is a lack of rigorous quantitative research at the secondary level that statistically assesses their effects on student learning outcomes, achievement, and attitudes. Manipulative items in basic arithmetic assist pupils in strengthening their cognitive skills (Gravito et al., 2023), there is little emphasis on middle school math for Grade 8. Few recent secondary math studies employ manipulative-based instruction in geometry with rigorous quantitative designs, despite geometry being a fundamental curriculum area (Ejiofor-Chima, 2025)

In the researcher's environment, the Grade 8 students of the University of Cebu Pardo and Talisay struggled to comprehend mathematical concepts. Traditional teaching approaches, while helpful for some, do not always fully engage students with varied learning styles when dealing with complex and difficult subjects, which can create gaps in their comprehension. Some students rely on manipulatives for additional support, such as algebra tiles, geometric forms, popsicle sticks, snakes and ladders, rope challenges, and a wheel of multiplication, which made mathematics more engaging and enjoyable. However, there is no formal research to confirm whether this practice improves learning outcomes or merely supplements traditional instruction.

The study aims to address the methodical gaps by assessing the effectiveness of using manipulatives in teaching Grade 8 Mathematics through a quantitative study at the University of Cebu at Pardo and Talisay.

## 2. Framework

This study is anchored on Jean Piaget's Cognitive Development Theory (1950), supported by Jerome Bruner's Constructivist Theory (1960) and John Dewey's Learning by Doing (1856), which collectively highlight that learning is most effective when active, hands-on, and socially supported.

Cognitive development is how people acquire, process, and expand their knowledge and understanding throughout time, moving from fundamental, concrete thinking to more complex, abstract reasoning, Piaget's (1950). Jean Piaget's Cognitive Development Theory provides a framework for understanding how children learn and grow intellectually, particularly when using mathematical manipulatives. He emphasized that children are active learners who build their understanding of the world through interaction with their surroundings. This is consistent with the use of manipulatives, which give practical, hands-on experiences that help students internalize new mathematical concepts and adjust their schemas (Sidik, 2020).

Additionally, Piaget explained during the Sensorimotor Stage and to the Pre-Operational stage, infants learn about their environment through sensory experiences and motor activity that are characterized by the development of symbolic thinking and language use. This stage is primarily concerned with physical engagement, mathematical manipulatives such as shape sorters or stacking toys, counting blocks, fraction circles, or number lines, which help them visualize mathematical concepts that assist kids in developing fundamental abilities such as pattern recognition, spatial connections and mathematical skills. Manipulatives at this time promote curiosity and investigation laying the groundwork for future learning.

Jean Piaget also explained in his theory between the Concrete Operational Stage and the Formal Operational Stage, children acquire logical thinking skills and the capacity to conduct operations on physical objects. Mathematical manipulatives can help students learn concepts like place value, multiplication, and division. During this stage, children understand concepts such as conservation and classification, and manipulatives give the hands-on experiences required to enhance these abstract notions.

Piaget's approach emphasizes the necessity of concrete examples and metacognition in this stage aligns with the reflective use of manipulatives, allowing students to analyze their reasoning and deepen their mathematical understanding.

Secondly, this study maintains Jerome Bruner's Constructivist Theory (1960). Bruner explained in the Constructivist Theory that teaching and learning philosophy stresses learners' active participation in developing their understanding and knowledge through experiences and interactions. It is based on the premise that learning is an active process in which people interact with their surroundings, existing knowledge, and new information to make sense of concepts. Bruner introduces exploration learning, which involves pupils interacting with resources and exploring topics to gain a better understanding.

In addition, Bruner's Theory highlights the integration of three kinds of representation: enactive, iconic, and symbolic. During the enactive stage, students rely on direct manipulation and activity. Mathematical manipulatives, such as counting beads, blocks, or tangrams, give children real experiences that help them understand fundamental ideas. This shows the relevance of physical engagement with things in developing mental representations as well as the Iconic and symbolic stage that employs visual tools to help learners organize information and involve the use of abstract symbols, such as numbers and equations, which are crucial for understanding more complex concepts. This demonstrates how manipulatives serve as transitional tools, guiding students from hands-on learning to abstract reasoning (Ozdem-Yilmaz & Bilican, 2020)

To sum it up, Bruner's Constructivist Theory emphasizes the benefits of spiral learning, in which students revisit topics at increasingly complex levels. Mathematical manipulatives played an important part in this process, given that they allowed students to explore and re-examine concepts at different levels of representation. Educators may give chances for student investigation, reflection, and conceptual progress by including manipulatives in the learning process. This theory aligns with the use of mathematical manipulatives, which enable students to explore and discover mathematical correlations (Bruner, 1974).

Lastly, another supporting theory of Experiential education is based on John Dewey's learning-by-doing philosophy (1856), which highlighted that education is most effective when students actively engage in real-world events. Learning by doing refers to a method of acquiring knowledge or skills through direct, active participation in a task or experience where individuals learn primarily by performing and observing the results, rather than solely through passive learning like lectures or reading. Dewey believed that learning should be interactive and linked to the practical application of knowledge. This mindset is strongly related to the use of mathematical manipulatives, which give hands-on opportunities for students to explore mathematical ideas and apply their knowledge to a meaningful learning experience.

Moreover, Dewey's Theory underscores the significance of participation and reflection during the learning process. When students utilized manipulatives such as base-ten blocks or fraction circles, they actively participate in developing their grasp of place value and fractions. This participation allows kids to create improves their understanding. Reflection is also important, as students assess their experiences with manipulatives to form conclusions and strengthen their mathematical foundation. The idea is that learning should be student-centered and inquiry-driven, encouraging curiosity and problem-solving by allowing students to experiment and discover solutions on their own (Furman, 2017).

As a result, Dewey's Theory promotes the integration of knowledge and experience across disciplines. Collaboration is another significant experience that mirrors real-world problem-solving scenarios, preparing students for future challenges and emphasizing the social aspect of learning. Mathematical manipulatives exemplify this notion by linking mathematics to everyday life and other topics. Tools such as measuring manipulatives may connect math and science, whereas graphing manipulatives connect math and social studies. This multidisciplinary theory, supported by experiential learning, ensures that students see the importance of mathematics in their lives and gain a comprehensive grasp of the world around them (Rosli et al., 2015b).

To exemplify, more recent research, such as that conducted by Carbonneau et al. (2013), showed that manipulatives greatly increase conceptual comprehension and procedural abilities when utilized effectively in mathematics instruction. It also explored certain cognitive difficulties when teachers use arithmetic manipulatives to educate. It discussed many of the most regularly used math manipulatives in today's schools and compares them to some of the Common Core Math Standards taught in classrooms across the United States and the world.

In this regard, (Hurst & Linsell, 2020) showed that students use manipulatives (arrays, base ten blocks) to work out the solution to a two-digit by two-digit multiplication example. Galvez et al., (2023) emphasized that when students employ manipulatives, they obtain a higher conceptual grasp than traditional approaches. Teachers adopt manipulatives in the teaching and learning process because they allow students to learn and develop new abilities. Depending on their qualities and nature, certain manipulatives develop several skills. Skills development differs based on the task and the manipulatives utilized Campilla and Castañaga (2021).

Mathematical manipulatives are useful because they help pupils go from abstract mathematical concepts to physical representations, facilitating higher-level thinking (Kazi and Galanaki 2020). He highlighted that children go through phases of

cognitive development, evolving from concrete to more abstract reasoning as they age. Students may utilize tangible items to comprehend complicated concepts in the Concrete Operational Stage. Sidik (2020), actualizing Jean Piaget's theory of cognitive development in learning by using manipulatives, was quite influential in education. Bungao-Abarquez (2020) added that mathematical manipulatives are artifacts used in mathematics education. Students use them to explore, acquire, or investigate mathematical concepts or processes and perform problem-solving activities that rely on perceptual evidence.

Marley et al., (2015) the practical application of mathematical manipulatives is examined using cognitive theories in research and highlighted that manipulatives work best when used in conjunction with instructional supervision. Their findings are consistent with the Cognitive Development Theory of Jean Piaget, which emphasizes the shift from concrete to abstract thinking. Moreover, Monte, J. (2021). emphasized the need for consistent usage, moving from tangible tools to abstract thinking, and making sure manipulatives are made to emphasize key mathematical ideas. The results offered a solid theoretical foundation for using manipulatives in arithmetic instruction.

Moreover, Ahmad (2024) described manipulatives and other tools that support enactive and iconic learning to help pupils make the shift to symbolic representation. Hassan et al., (2022) mentioned the spiral curriculum, which allows students to repeat subjects at progressively higher degrees of complexity, is a fundamental component of Bruner's methodology. This guarantees a steady increase in comprehension, starting with fundamental notions and working up to more sophisticated ones.

Furthermore, Gonulal and Loewen (2018) mentioned that scaffolding is another fundamental component of Bruner's Theory, in which teachers offer pupils directed assistance as they progress toward learning independence. To make learning relevant to students' experiences and meaningful, he also emphasized the significance of integrating cultural and social settings into education. His constructivist methodology has had a big impact on contemporary teaching methods, promoting active learning techniques that emphasize participation, critical thinking, and problem-solving. Cooperstein and Kocevar- Weidinger (2004), stresses that learning is an active process in which students create new information based on their existing understanding, which complements Piaget's theory.

Hence, Murti (2021) reinforced this viewpoint, claiming that manipulatives help learners go from concrete representations to abstract concepts, mirroring Dewey's conviction in the significance of sequential, experiential learning phases. Dewey's Learning by Doing provides a strong theoretical foundation for integrating manipulatives into mathematics education. Supported by scholars like Boggan et al. (2010) & Kilgour et al. (2015), their insights affirm the value of experiential, contextual, and social learning in developing critical 21st-century mathematical skills.

Additionally, Abbey (2016) embraces children's inherent ability to develop their knowledge through active learning has significant significance. Educators should provide compelling learning situations that encourage imagination and creativity to help students build knowledge. Tan (2020) believes that teachers' opinions regarding using mathematical manipulatives to teach numbers, as well as how these ideas influence their instructional choices and classroom practice. The impact of instructional manipulatives' perceptual and interactive complexity on learning, which is critical for transferring knowledge to new contexts, without reliance on manipulatives (Pouw et al., 2014).

Saleem et al. (2021) shared that incorporating manipulatives into instruction has been connected to constructivist learning techniques. A collaborative learning strategy focuses on student participation, debate, and knowledge sharing. It focused on how students engage with physical or digital instruments to actively generate knowledge, particularly in difficult arithmetic topics. This method is consistent with modern pedagogies that emphasize experiential learning (Furner, 2024).

Furthermore, Parungao (2021) examined the efficiency of conventional techniques with manipulatives for teaching fractions to high school pupils in the Philippines. The study discovered that employing both tangible and virtual manipulatives considerably enhanced students' grasp of specific fractional procedures. This is consistent with cognitive theory since it emphasized the relevance of hands-on learning in improving problem-solving abilities and retention. The study suggests using manipulatives to promote dynamic and engaging learning settings.

Japitana (2018), a recent study in the Philippines on social constructivism from 2020 to 2024, highlights its success in improving cooperation, critical thinking, and involvement in student learning. Japitana's study at Saint Michael College in Caraga looked at the effects of social studies classes taught using manipulatives. It emphasized the need to mix techniques to improve general engagement and critical thinking.

Gravito et al. (2023) mentioned that manipulative materials enable mental representations of abstract mathematical notions and procedures. It stimulates students and boosts their interest in math. The researchers suggested that employing handcrafted manipulative materials might improve mathematics performance in Grade IV students at a public primary school on Bantayan Island, located on the northern point of Cebu, Philippines. It is emphasized that using manipulative objects in primary math helps

students improve their cognitive skills. Learning is quickly absorbed with real-world manipulative items that students may touch and concretize. Homemade manipulative items, such as bottle caps, pebbles, and shells, can effectively teach mathematical concepts using handmade manipulative items to teach math to young learners is a cost-effective way to recycle locally available resources.

Moyer-Packenham and Westenskow (2016) examine how manipulative and visual models help conceptualize fractions at the University of the Visayas, Cebu City. The researcher discovered that students require intervention in the form of manipulative and visual models, with intervention being the extra teaching and exercises required to suit an understudy's circumstances and demands. Effective intervention involves selecting appropriate strategies and educational materials. According to the study, manipulative and visual models can boost pupils' academic performance in the National Council of Teachers' conceptualization of fractions of Mathematics (NCTM, 2000). Principles and Standards for School Mathematics image was regarded as one of the important methods in the instruction and learning of math, having the ability to teach mathematics effectively obliges teachers to pick the kinds of representations that will support important mathematics learning in classrooms.

To this end, guided by the anchor theory, supporting theories, related literature, and prior study, this study was conducted to assess the effectiveness of using manipulatives in teaching Grade 8 mathematics at the University of Cebu at Pardo and Talisay. The findings of this study contributed to the growing body of literature on innovative instructional strategies and provided evidence-based recommendations for enhancing mathematics education.

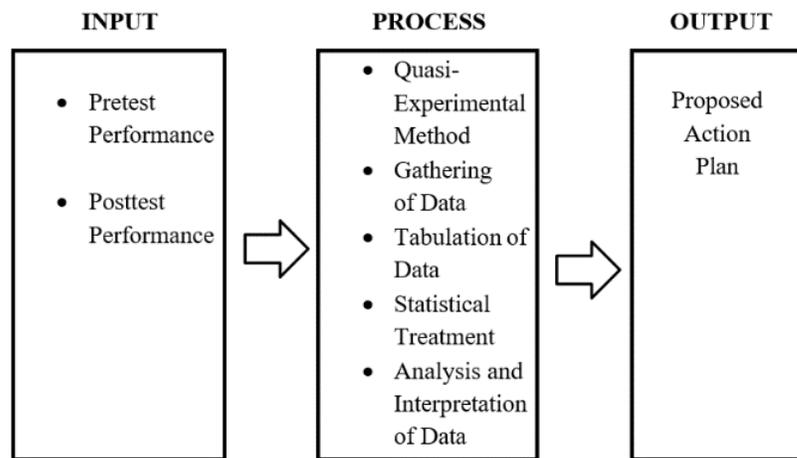
**3. Objectives of the Study**

The study assessed the effectiveness of using manipulatives in teaching Grade 8 Mathematics, University of Cebu Pardo and Talisay, Bulacao, Pardo, Cebu City, Philippines for S.Y. 2024-2025. Through the lens of the control and experimental group's pre-test and post-test scores, whether there is a significant difference between their pre and post-test scores and, finally, if a significant difference is observed between their post-test scores.

**4. Methodology**

**4.1 Research Design**

This quantitative study employed a quasi-experimental design, applied pretest and posttest, to assess the effectiveness of using manipulatives in teaching Grade 8 Mathematics. The quasi-experimental design allows for the comparison of two groups: an experimental group that has an integration of manipulatives and a control group that undergoes traditional instructional methods. Figure 1 shows the flow of the study.



**Figure 1**  
**Research Flow**

**4.2 Research Subjects**

The subjects in this study are sixty (60) of the Grade 8 students of S.Y. 2024-2025 who are officially enrolled in the Basic Education – Junior High School Department at the University of Cebu at Pardo and Talisay. The Grade 8 students are divided into two (2) groups, thirty (30) students for the Experimental group and thirty (30) students for the Control group. Each student in the Experimental group is paired with a student in the Control group in terms of gender and second-quarter grades. To illustrate the alignment between respondents in both groups, a matching table is constructed as shown in Table 1.

**Table 1**  
**Matching of Research Subjects**

Pair No.	Control Group	Control Group Gender	Second Quarter Grade	Experimental Group	Experimental Group Gender	Second Quarter Grade
1	Subject 1	Male	97	Subject 1	Male	97
2	Subject 2	Female	95	Subject 2	Female	96
3	Subject 3	Female	95	Subject 3	Female	94
4	Subject 4	Male	95	Subject 4	Male	96
5	Subject 5	Female	94	Subject 5	Female	94
6	Subject 6	Male	94	Subject 6	Male	95
7	Subject 7	Male	94	Subject 7	Male	94
8	Subject 8	Female	94	Subject 8	Female	93
9	Subject 9	Female	93	Subject 9	Female	93
10	Subject 10	Female	90	Subject 10	Female	91
11	Subject 11	Female	89	Subject 11	Female	89
12	Subject 12	Female	89	Subject 12	Female	88
13	Subject 13	Male	89	Subject 13	Male	89
14	Subject 14	Female	87	Subject 14	Female	87
15	Subject 15	Male	87	Subject 15	Male	87
16	Subject 16	Female	86	Subject 16	Female	85
17	Subject 17	Male	86	Subject 17	Male	86
18	Subject 18	Female	85	Subject 18	Female	85
19	Subject 19	Female	85	Subject 19	Female	85
20	Subject 20	Female	84	Subject 20	Female	83
21	Subject 21	Male	83	Subject 21	Male	83
22	Subject 22	Male	83	Subject 22	Male	82
23	Subject 23	Male	81	Subject 23	Male	81
24	Subject 24	Female	81	Subject 24	Female	81
25	Subject 25	Male	80	Subject 25	Male	80
26	Subject 26	Female	79	Subject 26	Female	78
27	Subject 27	Male	76	Subject 27	Male	77
28	Subject 28	Male	75	Subject 28	Male	76
29	Subject 29	Male	75	Subject 29	Male	76
30	Subject 30	Male	75	Subject 30	Male	75

#### 4.3 Research Procedure

**Data Gathering.** A transmittal letter was submitted for approval to the Basic Education Principal asking permission to conduct the study. After the request is granted, the researcher conducted a pre-test for all participants in Grade 8. The participants were divided into two (2) groups, the control group and the experimental group, and both groups took the pre-testing. After the pretest, the experimental group had lecture-based instruction integrating manipulatives, while the control group continued with lecture-based instruction. The researcher discussed concepts of axiomatic geometry structure and triangle congruence from the K-12 Curriculum Guide, with eight (8) Most Essential Learning Competencies. This includes: 1.) describes a mathematical system, 2.) illustrates the need for an axiomatic structure of a mathematical system in general, and in Geometry in particular: (a) defined terms; (b) undefined terms; (c) postulates; and (d) theorems, 3.) illustrates triangle congruence, 4.) illustrates the SAS, ASA and SSS congruence postulates, 5.) solves corresponding parts of congruent triangles, 6.) proves two triangles are congruent, 7.) proves statements on triangle congruence, 8.) applies triangle congruence to construct a perpendicular lines and angle bisectors. The teaching and learning activity lasted for 21 hours. After all the interventions, both groups were administered a posttest using the same test paper as the pretest to check any changes in their mathematical performance, then, after the checking was done, gather all data,

tally, and interpret the study's results. The student's responses were compiled and analyzed, serving as the primary data for the study. To ensure that no personal information about the research subject is disclosed, the names of the respondents remained anonymous.

### 5. Results and Discussion

This chapter deals with the presentation, analysis, and interpretation of data gathered from the control groups and experimental groups of the study.

#### Pretest Performances

This section presents the pretest performances of the control and experimental groups. Table 2 summarizes the pretest performances.

**Table 2**  
**Pretest Performances of Control and Experimental Groups**

A. Control Group Pretest	Score Ranges	Frequency	Percent
Fair	18 to 24	1	3%
Did Not Meet Expectation	0 to 17	29	97%
B. Experimental Group Pretest	Score Ranges	Frequency	Percent
Fair	18 to 24	4	13%
Did Not Meet Expectation	0 to 17	26	87%
Total		n = 30	100%

Legend: Very Satisfactory = (32 to 35); Satisfactory = (25 to 31); Fair = (18 to 24); Did Not Meet Expectation (0 to 17)

Table 2 shows that the pretest results reveal that the control and experimental groups had the most students who did not meet expectations. In the control group, only 1 out of 30 students (3%) scored within the fair range of 18 to 24, while the remaining 29 students (97%) scored between 0 to 17, indicating they did not meet expectations. In contrast, the experimental group showed slightly better performance, with 4 students (13%) achieving scores within the fair range, and 26 students (87%) did not meet expectations, which in general, the experimental group demonstrated a modest improvement in pretest performance compared to the control group, though both groups had a significant number of students requiring further academic support.

Based on these results, which show that the majority of students in both the control and experimental groups did not meet expectations, with only slight differences in performance, the data imply that Grade 8 students had limited prior understanding of the mathematical concepts covered in the study. This suggests a strong need for more effective instructional strategies to support foundational learning. The slightly better performance of the experimental group, even before the intervention, indicates a possible early advantage or familiarity with hands-on learning. These highlight the importance of using engaging and concrete teaching methods, such as manipulatives, to enhance students' conceptual understanding and address learning gaps at the outset of instruction.

This finding is supported by the study of Carbonneau et al. (2013), when the result indicated that students had low starting scores across studies reviewed, but groups exposed to manipulatives demonstrated slightly better engagement and learning gains after instruction, even when both groups started weak. As well as Moyer, P. S. (2001), pre-instruction observations noted that students had low performance regardless of the method. However, when manipulatives were introduced, there was a visible but initially small advantage in problem comprehension for the experimental group.

#### Posttest Performance

This section presents the posttest performances of the control and experimental groups. Table 3 summarizes the posttest performances.

**Table 3**  
**Posttest Performances of the Control and Experimental Groups**

Control Group Posttest	Score Ranges	Frequency	Percent
Very Satisfactory	32 to 35	1	3%
Satisfactory	25 to 31	6	20%
Fair	18 to 24	7	23%
Did Not Meet Expectation	0 to 17	16	53%
Experimental Group Posttest	Score Ranges	Frequency	Percent
Very Satisfactory	32 to 35	9	30%
Satisfactory	25 to 31	13	43%
Fair	18 to 24	8	27%
Total		n= 30	100%

Legend: Very Satisfactory = (32 to 35); Satisfactory = (25 to 31); Fair = (18 to 24); Did Not Meet Expectation (0 to 17)

Table 3 presents that the posttest results showed a notable improvement in the performance of the experimental group compared to the control group. In the control group, only 1 student (3%) reached the very satisfactory level, while 6 students (20%) were classified as satisfactory, and 7 students (23%) achieved a fair rating. However, more than half of the control group, 16 students (53%), still fell into the did not meet expectation category. On the other hand, the experimental group performed significantly better, with 9 students (30%) achieving very satisfactory scores, 13 students (43%) reaching satisfactory, and the remaining 8 students (27%) falling within the fair range. Notably, none of the experimental group students scored in the did not meet expectation range. These results indicate that the experimental group showed considerable improvement after the intervention, suggesting its effectiveness in enhancing student performance.

These results indicate a significant positive impact of using manipulatives in teaching Grade 8 Mathematics. While the control group showed only minimal improvement, with over half of the students still not meeting expectations, the experimental group demonstrated substantial gains, with 100% of the students achieving at least a fair level of performance and the majority reaching satisfactory to very satisfactory levels. This clear contrast suggests that manipulatives effectively support students' understanding of mathematical concepts, translating into higher achievement levels. This implies that incorporating manipulatives into instruction not only enhances conceptual clarity but also boosts student performance, making it a valuable strategy for improving outcomes in middle school mathematics.

This finding is similar to Witzel et al. (2003), students in the experimental group who received instruction with manipulatives and visual supports outperformed the control group in post-instruction assessments. The study concluded that concrete-to-representational-to-abstract (CRA) strategies significantly boost student performance.

#### Significant Difference Between Pretest Performances

This section presents the results of the tests conducted on the significance of the increase in the performance of the students in the control and experimental groups. Table 4 summarizes the results of the conducted tests of the hypothesis.

**Table 4**  
**Significance of the Differences Between the Pretest Performances of the Control and Experimental Groups**

Subjects'	n	Mean	SD	Ind. t-test Value	p-Value	Decision Ho	Remarks
Pretest Scores							
A. Control Group	30	13.93	4.35	2.754	0.008	Reject Ho	Significant
B. Experimental Group	30	17.43	5.44				

As shown in Table 4, the independent t-test results for the pretest scores show a statistically significant difference between the control and experimental groups. The control group had a mean score of 13.93 with a standard deviation of 4.35, while the experimental group had a higher mean of 17.43 and a standard deviation of 5.44. The computed t-value of 2.754 and a p-value of 0.008, which is less than the 0.05 significance level, led to the rejection of the null hypothesis. This indicates that there was a

significant difference in the pretest performance between the two groups, with the experimental group performing better even before the intervention.

The statistically significant difference in pretest scores between the control and experimental groups implies that students in the experimental group may have had prior exposure, better foundational understanding, or early familiarity with hands-on learning methods, giving them an initial advantage. This highlights the importance of accounting for pre-existing academic differences when comparing instructional approaches and suggests that while manipulatives are effective, their impact can be influenced by students' prior knowledge or learning experiences. Therefore, careful consideration should be given to group assignment and baseline equivalence in future studies to ensure more accurate measurement of instructional effects.

This finding is comparable to the research of Clements et al. (2007). Statistical analysis showed that the experimental group began with a slightly higher mean performance in pretests, suggesting pre-existing differences in exposure or learning styles. Despite this, the program still demonstrated a significant impact post intervention.

**Significant Difference in the Performance of the Students**

This section presents the test results conducted on the significant difference between the pretest and posttest performance of the students in the control and experimental groups. Tables 5 and 6 summarize the results of the conducted test of the hypothesis.

**Table 5**  
**Test of the Significance of the Difference Between the Pretest and Posttest of Students’ Performances in the Control Group**

Control Group	n	Mean	SD	Paired t-test Value	df	p-Value	Decision	Remark
Pretest Scores	30	13.93	4.35	7.638	29	<0.001	Reject Ho	Significant
Posttest Scores	30	21.83	6.21					

As indicated in Table 5, the paired t-test results for the control group reveal a significant improvement from pretest to posttest scores. The mean pretest score was 13.93 with a standard deviation of 4.35, while the posttest mean increased to 21.83 with a standard deviation of 6.21. The computed t-value of 7.638 with 29 degrees of freedom and a p-value of less than 0.001 indicates that the difference is statistically significant at the 0.05 level. Thus, the null hypothesis is rejected, suggesting that the control group showed meaningful learning gains over time, even without the intervention applied to the experimental group.

It indicates that students made meaningful academic gains through traditional teaching methods alone. This improvement, confirmed by the paired t-test results, suggests that even without the use of manipulatives, structured and consistent instruction can lead to positive learning outcomes. It implies that while alternative strategies like manipulatives may enhance learning further, traditional approaches still have instructional value when delivered effectively. These results highlight the role of teacher effectiveness, curriculum pacing, and student adaptability in supporting achievement, even in the absence of hands-on learning tools.

Slavin et al. (2008), traditional teacher-directed instruction, especially when consistently implemented, can significantly improve student achievement. Even without manipulatives, strategies such as summarizing, reinforcing effort, and setting objectives yield significant academic improvements (Marzano et al., 2003).

**Table 6**  
**Test of the Significance of the Difference Between the Pretest and Posttest of Students’ Performances in the Experimental Group**

Experimental Group	n	Mean	SD	Paired t-test Value	df	p-Value	Decision	Remark
Pretest Scores	30	17.43	5.44	16.859	29	<0.001	Reject Ho	Significant
Posttest Scores	30	30.00	2.7					

As shown in Table 6, the paired t-test results for the experimental group show a highly significant improvement from pretest to posttest.

The mean pretest score was 17.43 with a standard deviation of 5.44, while the posttest mean increased markedly to 30.00 with a much lower standard deviation of 2.7. The computed t-value of 16.859 with 29 degrees of freedom and a p-value of less than 0.001 confirms that the difference is statistically significant at the 0.05 level. Therefore, the null hypothesis indicating that the intervention had a substantial positive effect on the performance of the experimental group.

The highly significant improvement in the experimental group's scores from pretest to posttest, as indicated by the large increase in the mean and a much lower standard deviation, implies that the use of mathematical manipulatives had a significantly and consistently positive impact on student learning. The significant increase in scores and reduced variability among students suggest that manipulatives not only enhanced conceptual understanding but also promoted more equitable learning outcomes across the group. This supports the idea that concrete, hands-on tools can bridge learning gaps and help students better internalize abstract mathematical concepts, making them an effective strategy in improving both performance and consistency in achievement.

Boggan et al. (2010) reveal that posttest results showed that students learning through manipulatives consistently outperformed peers taught using only traditional methods. As well as (Moyer, P.S., 2001), Students in manipulative-rich environments experienced greater learning gains and deeper engagement, reflected in higher test scores and lower performance variability.

### Significant Difference Between Posttest Performances

This section presents the posttest performances between the control and experimental groups. Table 7 summarizes the posttest performances.

**Table 7**  
**Significant Difference Between the Posttest Performances of Control and Experimental Groups**

Subjects'	n	Mean	SD	Ind. t-test Value	p-Value	Decision Ho	Remarks
Posttest Scores							
A. Control Group	30	21.83	6.20	6.61	<0.001	Reject Ho	Significant
B. Experimental Group	30	30.00	2.70				

Table 7 shows that the independent t-test results for the posttest scores indicate a statistically significant difference between the control and experimental groups. The control group had a mean score of 21.83 with a standard deviation of 6.20, while the experimental group achieved a higher mean of 30.00 with a standard deviation of 2.70. The computed t-value of 6.61 and a p-value of less than 0.001 lead to the rejection of the null hypothesis. This confirms that the experimental group performed significantly better than the control group after the intervention, highlighting the effectiveness of the treatment or strategy applied.

The significant difference in posttest scores between the control and experimental groups, as indicated by the independent t-test results, demonstrates that students taught with manipulatives achieved a deeper understanding of mathematical concepts compared to those taught using traditional methods. The higher mean and lower standard deviation in the experimental group's scores not only confirm better performance but also suggest more consistent learning across students. This implies that manipulatives effectively enhance both comprehension and retention, making abstract concepts more accessible. Moreover, the reduced variability indicates that manipulatives may help bridge learning gaps among diverse learners. Overall, the findings support the integration of manipulative-based instruction as a powerful strategy for improving mathematics achievement in middle school students.

This finding is comparable to the research of Witzel et al. (2003). Posttest scores revealed a marked advantage for students taught using the Concrete-Representational-Abstract (CRA) approach, confirming manipulatives' effectiveness. Cockett et al. (2015). Students using manipulatives performed significantly better on assessments, showing increased understanding, enjoyment, and consistency in learning outcomes. and Boggan et al., (2010), that study found a significant difference in performance favoring students who learned through manipulatives, particularly in understanding place value and operations.

### 6. Conclusion

Mathematical manipulatives significantly enhance students' academic performance in Grade 8. The experimental group consistently outperformed the control group in posttest scores, indicating more consistent and equitable learning outcomes. It affirms that manipulatives play a crucial role in promoting deeper conceptual understanding and engagement. These findings strongly support the integration of manipulatives as an effective instructional strategy to improve mathematics achievement, student engagement, comprehension, and support differentiated learning in mathematics classrooms.

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