Effect of Manipulatives on the Achievement of Grade 9 Students in Geometry

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ABSTRACT

This study investigated the effect of manipulatives on the achievement of Grade 9 students in Geometry for the school year 2024-2025. The respondents of this study were the ninety Grade 9 students in a public school in Negros Occidental. The researcher adopted a standardized test as the research instrument to enhance the reliability and validity of the study. The findings revealed that students who were exposed to the enhanced instructional approach showed greater improvement in their post-test scores compared to those who experienced the traditional method of teaching. This suggests that the strategy helped learners better understand the concepts and develop their problem-solving skills. Furthermore, the significant difference between the performances of the control and experimental groups confirms the effectiveness of the intervention in improving students' academic achievement.

Keywords: Manipulatives, achievement of Grade 9 students in Geometry, learning engagement, concrete learning materials, teaching strategy.

INTRODUCTION

Manipulatives are tangible mathematical instruments that allow students to learn through experience. Mathematics teachers can utilize manipulatives to capture students' interest, help them envision what they are doing (explain abstract concepts), and involve them in hands-on activities. Manipulatives ha ve long been acknowledged as valuable mathematical tools for delivering hands-on learning through tangible objects (Burns & Hamm, 2011 as cited by Adegboyega, 2023). Several kinds of manipulatives have been used throughout history to help people understand mathematical concepts.

Hurst and Linsell first heard about manipulatives seen as educational tools for teaching in the late 1800s. Teachers began using manipulatives to enhance their lessons and observed positive improvements in their students' mathematical skills. In the 1900s, Italian physician and educator Maria Montessori developed the use of manipulatives to enable children to learn through personal investigation and exploration (Hurst & Linsell, 2020).

In traditional grade-level mathematics classrooms, manipulatives have become essential tools for enhancing students' understanding of basic mathematical operations. This instructional approach involves the use of physical tools to enhance students' understanding of mathematical concepts. Teachers recognize the importance of using manipulatives to create effective, active, and engaging mathematics lessons. The use of manipulatives, or tangible objects, can accommodate a variety of learning styles and abilities within the classroom.

Using manipulatives in teaching Geometry is an effective way to help students understand abstract concepts by allowing them to engage physically and visually with shapes, angles, and geometric properties. The use of manipulatives can make learning more interactive, hands-on, and accessible, which enhances conceptual understanding, retention, and problem-solving skills.

Using manipulatives makes students active participants in the learning process rather than passive listeners. The increased engagement helps them internalize and reinforce geometric concepts through tactile exploration and experimentation.

Students may perform poorly on summative tests if they lack certain knowledge or have not fully understood the subjects being examined. The issue may be the result of poor instruction, content difficulty, or a lack of assistance. Poor mathematical performance may result from a variety of cognitive and environmental factors that significantly affect learning.

Manipulatives engage the body and mind, reinforcing memory through physical movement. The process of physically constructing shapes or solving problems with objects strengthens neural connections, which enhances the retention of geometric concepts. A large number of manipulative-based exercises are designed to be completed in pairs or groups. Students can exchange tactics, clarify their ideas, and gain knowledge from one another through this collaboration, which promotes communication, teamwork, and peer learning.

In this regard, the researcher conducted this study to determine the effect of using manipulatives on the achievement in Geometry of Grade 9.

METHODOLOGY

Research Design

This research utilized experimental quantitative research design with a pre-test post-test control group design. The study involved two groups of students: an experimental group and a control group. A quasi-experimental study is a quantitative research design in which participants are assigned into a treatment group for the purpose of testing the effectiveness of an intervention (Maciejewski, 2020). The experimental group utilized manipulatives in teaching Geometry, while the control group utilized conventional instruction. The design allowed for a comparative analysis of the effect of the manipulatives versus conventional teaching methods on student achievement in Geometry.

Subject and Respondents of the Study

The participants of this study were the Grade 9 students who came from the 2 selected sections whose class schedule starts at 10:10am -10:55am and 11:00am – 11:45am in one of the public high schools in Negros Island Region during the school year 2024-2025.

Population and Sample Size

The study engaged a total of 90 Grade 9 participants, with 45 students assigned to the experimental group and 45 students assigned to the control group. In the 10:10–10:55 a.m. class, only 45 out of 47 students were included in the study due to the availability of complete pre-test and post-test data. Similarly, in the 11:00–11:45 a.m. class, only 45 out of 48 students were included, as one student had no pre-test record while the other two students had no post-test recorded. Therefore, only students with complete pre-test and post-test results were considered in the final data analysis.

Data Gathering Instrument

The study utilized a standardized data gathering instrument to measure computer literacy of the students. It was The primary instrument used in this study was a standardized summative test obtained from the School Division Office. The test was designed and validated by subject specialists to assess the learners' knowledge and competencies in Geometry based on the prescribed learning standards of the Department of Education (DepEd).

Aside from the research instrument, the manipulatives utilized in the lessons were evaluated and validated by the Master Teachers to ensure their appropriateness, accuracy, and alignment with the learning objectives.

Data Analyses

The data were retrieved, encoded, and processed using the Statistical Software. To answer the statement of the problem 1, which determined the pre-test and post-test achievement in Geometry of Grade 9 students under the experimental group, the mean and standard deviation were used.

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Formula for mean: $\bar{x} = \frac{\sum x}{n}$

Where: $\bar{x}$ = mean

$\sum$ = summation notation

x = scores

n = sample size

To further interpret the results, the obtained scores were interpreted using the common educational standards in the Philippines (such as DepEd Order no. 160).

Score Range out of 40	Mastery Level
39-40	Mastered
35-38	Closely Approximating Mastery
27-34	Moving Towards Mastery
14-26	Average Mastery
6-13	Low Mastery
2-5	Very Low Mastery
0-1	Absolutely No Mastery

The mean and standard deviation in problem number 1 were interpreted as follows:

Group Test	f	Mean	SD	Interpretation
Pre-test	45	11.44	2.15	Low Mastery
Post-test	45	20.29	3.63	Average Mastery

To answer the statement of the problem 2, which determined the pre-test and post-test achievement in Geometry of Grade 9 students under the experimental group, the mean and standard deviation were used.

The mean and standard deviation in problem number 2 were interpreted as follows:

Group Test	f	Mean	SD	Interpretation
Pre-test	45	11.84	3.08	Low Mastery
Post-test	45	29.59	4.76	Moving Towards Mastery

To answer the statement of the problem 3, which determined if there was a significant difference between the pre-test and post-test achievement in Geometry of Grade 9 students under the experimental group, the paired t-test was used.

Formula for Paired T-test:

$$t = \frac{(\sum D)/N}{\sqrt{\frac{\sum D^2 - \left(\frac{(\sum D)^2}{N}\right)}{(N-1)(N)}}}$$

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D = the mean difference between pre-test and the post test

ΣD^2 = the sum of squares of the difference between pre-test and post- test.

n= the sample size

The paired t-test in problem number 3 were interpreted as follows:

Experimental Group	f	Mean	Test Statistics (r)	p-value	Decision for Ho	Interpretation
Pre-Test	45	11.84	/-44.904/	<.001	Reject Ho	Significant
Post-Test		29.58				

To answer the problem number 4, which determined if there is a significant difference between the post-test achievement of Grade 9 students in Geometry under the control and experimental group, the t-test for independent sample was used.

Formula of T-test for Independent Sample:

$$t = \frac{X_1 - X_2}{\sqrt{\frac{SD_1^2}{N_1} + \frac{SD_2^2}{N_2}}}$$

where,

t = t-test

X_1 = Mean of the first variable

X_2 = Mean of the second variable

$SD_1{}^2$ = Variance of the first variable

$SD_2{}^2$ = Variance of the second variable

N_1 = Number of cases of the first variable

N_2 = Number of cases of the second variable

The t-test for independent sample in problem umber 4 were interpreted as follows:

Group	f	Mean	Test Statistics (r)	p-value	Decision for Ho	Interpretation
Controlled Group	45	20.29	-10.411	<.001	Reject Ho	Significant
Experimental Group	45	29.58				

RESULTS AND DISCUSSION

This chapter presents, analyzes, and interprets the data gathered in the study. The information is arranged in an organized manner to clearly address the research questions and objectives, with the use of appropriate statistical methods and tools for accurate interpretation of the results.

Pre-test and Post-test Achievement in Geometry of Grade 9 Students under the Controlled Group

Table 3 presents the pre-test and post-test achievements in Geometry of Grade 9 students under the controlled group in a public high school in Negros Occidental for school year 2024-2025.

Table 3. Pre-test and Post-test Achievements in Geometry of Grade 9 Students under the Controlled Group.

Group Test	f	Mean	SD	Interpretation
Pre-test	45	11.44	2.15	Low Mastery
Post-test	45	20.29	3.63	Average Mastery

Legend: (39-40)-Mastered; (35-38)-Closely Approximating Mastery; (27-34)-Moving Towards Mastery; (14-26)- Average Mastery; (6-13)-Low Mastery; (2-5)-Very Low Mastery; (0-1)-Absolutely No Mastery

The table shows the pre-test and post-test achievements in Geometry of Grade 9 students under the controlled group. The students' mean score on the pre-test is in low mastery (M= 11.44, SD= 2.15). This suggests that at the beginning, most students had limited understanding of the Geometry concepts.

After the lessons, the post-test results improved, with a mean score of (M= 20.29, SD= 3.63), interpreted as average mastery. This signifies that the students were able to develop a better comprehension of the lessons over time.

Overall, the results show that while there was noticeable improvement in the students' performance, their level of mastery remained moderate. This suggests that although the teaching approach used in the control group helped enhance learning, more work has to be done to reach a greater degree of geometry proficiency.

The result of this study is in consonance with the statement of Hanafiah (2022) which defines conventional teaching as a teacher-centered approach that employs whole-class instruction, focusing on explicit, deductive presentation of grammatical rules. In this setting, the teacher directs the learning process, and students primarily receive information passively. Hanafiah's research indicates that while this method provides structured content delivery, it may not sufficiently engage students or address individual learning needs.

Grade 9 Students under the Experimental Group

Table 4 presents the pre-test and post-test scores in Geometry of Grade 9 students under the experimental group in one of the public high schools in Negros Occidental for school year 2024-2025.

Table 4. Pre-test and Post-test Scores of Grade 9 Students in Geometry under Experimental Group.

Group Test	f	Mean	SD	Interpretation
Pre-test	45	11.84	3.08	Low Mastery
Post-test	45	29.59	4.76	Moving Towards Mastery

Legend: (39-40)-Mastered; (35-38)-Closely Approximating Mastery; (27-34)-Moving Towards Mastery; (14-26)- Average Mastery; (6-13)-Low Mastery; (2-5)-Very Low Mastery; (0-1)-Absolutely No Mastery

The table presents the performance of the Grade 9 students in a public high school in Negros Occidental in the experimental group before and after the Geometry lessons. With a mean score of (M= 11.84, SD= 3.08), on the pre-test, the students' performance is interpreted as low mastery. This suggests that at the beginning, the students had limited understanding of the Geometry concepts, similar to a typical starting point before instruction.

After the intervention, the post-test results show a noticeable improvement. The mean score increased to (M= 29.58, SD= 4.76), interpreted as moving towards mastery. This indicates that after being exposed to the teaching method applied in the experimental group, the students were able to greatly improve their comprehension and proficiency in geometry.

Overall, there has been a noticeable improvement in performance of the students. The large increase in mean score suggests that the strategy applied was effective in helping students learn and better grasp the concepts, moving them closer to mastery.

The finding is closely similar to the claim of Higgins et al. (2021) that students who use manipulatives are more likely to understand complex topics like angles, symmetry, and 3D shapes, as they can physically see and touch these concepts in action. This leads to better conceptual understanding and retention.

Difference Between the Pre-Test and Post-Test Achievement in Geometry of Grade 9 Students Under the Experimental Group

Table 5 presents the difference between the pre-test and post-test achievement in Geometry of Grade 9 students under the experimental group in one of the public high schools in Negros Occidental for school year 2024-2025.

Table 5. Difference Between the Pre-test and Post-test Achievement in Geometry of Grade 9 Students under the Experimental Group.

Experimental Group	f	Mean	Test Statistics (r)	p-value	Decision for Ho	Interpretation
Pre-Test	45	11.84	/-44.904/	<.001	Reject Ho	Significant
Post-Test		29.58				

The table shows the difference between the pre-test and post-test achievement in Geometry of Grade 9 students under the experimental group. The results show that the students obtained a mean score of 11.84 in the pre-test, indicating a low level of mastery before the intervention. After the implementation of the intervention, the students' mean score increased to 29.58, suggesting a considerable improvement in their performance.

The computed test statistic of -44.904 with 44 degrees of freedom and a p-value of less than 0.001 shows that the difference between the pre-test and post-test scores is statistically significant. This indicates that the students' improved performance is not the result of chance.

Overall, the results indicate that the experimental group's teaching approach improved the students' comprehension and performance in geometry.

The findings of the study corroborate with the findings of (Linaza et al., 2025) that manipulatives help bridge the gap between concrete and abstract thinking, fostering deeper conceptual understanding.

Difference Between the Post-Test Achievement in Geometry of Grade 9 Students Under the Controlled and Experimental Groups

Table 6 presents the difference between post-test achievement in Geometry of Grade 9 students in one of the public high schools in Negros Occidental for school year 2024-2025.

Table 6. Difference Between the Post-test Achievement in Geometry of Grade 9 Students under the Controlled and Experimental Groups.

Group	f	Mean	Test Statistics (r)	p-value	Decision for Ho	Interpretation
Controlled Group	45	20.29	-10.411	<.001	Reject Ho	Significant

Experimental Group	45	29.58				

Table 6 shows a clear difference in how the two groups performed after the lessons. The experimental group received a higher mean score of 29.58 than the controlled group, which received a mean score of 20.29.

The computed test statistic value of -10.411 and a p-value of less than .001 indicates that there is a significant difference between the post-test achievement in Geometry of Grade 9 students under the controlled and experimental groups. Since the p-value is lower than the level of significance, the null hypothesis was rejected.

The findings imply that the teaching strategy used in the experimental group was more effective than the method applied in the control group. The Grade 9 students of a public school in Negros Occidental exposed to the intervention demonstrated higher achievement in Geometry, suggesting that the strategy contributed positively to improving their understanding and learning performance.

The findings are consistent with the study of Cameron et al. (2020) that students who learned geometry using manipulatives were able to recall and apply geometric concepts more accurately in follow-up assessments compared to those who were taught using traditional methods.

CONCLUSION

From the results of the study, the following conclusions were drawn: Students in the control group started with a low level of understanding in Geometry but were able to improve after the lessons. They demonstrated that learning had occurred as their performance improved from low mastery to average mastery. The fact that their level only attained ordinary competence, however, implies that although the teaching strategy was beneficial, it was insufficient to fully establish a solid grasp of the topics. Students in the experimental group started with a low level of understanding in Geometry but improved significantly after the intervention. Their performance improved from low mastery to mastery, demonstrating a significant growth in both knowledge and abilities. This shows that the experimental group's teaching approach was very successful in improving students' comprehension and application of geometry ideas, resulting in a significantly greater level of learning than their beginning performance. The results show that the students performed better after the intervention. They learnt and improved in Geometry over time, as evidenced by the discernible difference between their pre-test and post-test results. This means that the experimental group's instruction was beneficial and improved their comprehension of the lessons. The results show that the two groups did not perform the same after the lessons. The students in the experimental group most likely profited more from the teaching strategy employed, based on the difference in their post-test scores. To put it simply, the method applied to the experimental group seems to have helped them understand Geometry better compared to those in the control group.

REFERENCES

1. Adegboyega, S. M., J C Amadi, J. C., Isaac Taley, I., Hamidu Ibrahim Bukari, H. I. (2023). Trends in Primary and Secondary School Mathematics Education (pp.222-232). KATAPUNO-PRINTS. https://www.researchgate.net/publication/376313200_CHAPTER_21_USE_OF_MANIPULATIVES_FOR_MATHEMATICS_TEACHING_AND_LEARNING
2. Sowell, E. J. (1989). Effects of Manipulative Materials in Mathematics Instruction. Journal for Research in Mathematics Education, 20(5), 498–505.
3. Apsari, R. A., & Abrahamson, D. (2024). Embodied geometry in movement: Using spatial sense to model abstract concepts. Educational Studies in Mathematics.
4. Artigue, M., et al. (2020). Using Manipulatives to Support Diverse Learners in Mathematics Education. Journal of Educational Research, 113(4), 411-421.
5. Benjamin J. Norton. (2022)."Traditional versus Modern Teaching Styles: Effect on Mathematical Achievement and Motivation," published in May 2022.https://cdn.ymaws.com/www.psichi.org/resource/resmgr/journal_2024/29_150_norton.pdf

6. Broadbent, J., Sharman, S. J., & Fuller-Tyszkiewicz, M. (2023). Designing effective summative post-assessments in blended higher education. Assessment & Evaluation in Higher Education, 48(4), 512–526.
7. Chris Hurst and Chris Linsell. (2020). "Manipulatives and Multiplicative Thinking" by, published in the European Journal of STEM Education in 2020. 5(1), 04 ISSN: 2468-4368
8. Christine M. Higgins, et al. (2022). "Propensities by Grade of Math Anxiety Levels K-12: Addressing Mathematics Dispositions and How Manipulatives May Help. https://nsuworks.nova.edu/transformations/vol8/iss1/1/
9. Clements, D. H., & Sarama, J. (2021). Learning and Teaching Early Math: The Learning Trajectories Approach (3rd ed.). Routledge. (Analyzes the cognitive bridge between physical and computer-based virtual manipulatives).
10. Dienes, Z. P. (2023)."Mathematics Manipulatives: Base 10" https://www.tts-group.co.uk/blog/2023/02/21/maths-manipulatives-base-10-dienes.html
11. **Ertmer, P. A., & Newby, T. J. (2013).** "Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from an Instructional Design Perspective." Performance Improvement Quarterly, 26(2), 43-71. https://doi.org/10.1002/piq.21143
12. Gu, X., & Luo, Y. (2023). Formative assessment mechanisms in blended learning and technology-enhanced environments. Educational Psychology Review.
13. Ginsburg, H. P., Pappas, S., & Lee, Y. (2010). Early Mathematics Assessment System. (Project number 1 RO1 HD051538-01). https://vkrponline.org/wp-content/uploads/sites/3/2022/10/EMAS-Overview-2022-10-14_svl.pdf
14. Hanafiah, W. O. (2022). Conventional Teaching Method and an Interactive-Based Teaching Methods to Adjust Learners' Grammar and Speaking Competence in English Classrooms: A Comparative Study for Effectiveness Methods in Learning. Eduvelop: Journal of English Education and Development, 6(1), 79–90. https://doi.org/10.31605/eduvelop.v6i1.1957
15. Jablonski, S., & Ludwig, M. (2023). Teaching and Learning of Geometry—A Literature Review on Current Developments in Theory and Practice. Education Sciences, 13(7), 682. https://doi.org/10.3390/educsci13070682
16. Lamon, S. J., & Turner, M. (2006). Teaching Mathematics with Manipulatives: How Teachers Can Promote Deep Understanding.
17. Linaza, N. K. D., Gultiano, S. R. O., & Susada, B. L. (2025). Enhancing Grade 4 students' mathematical problem-solving skills using manipulatives. Davao Research Journal, 16(1), 69–80. https://doi.org/10.59120/drj.v16i1.303
18. Maurya, R. (2026). Modern teaching strategies in mathematics: A comprehensive review of conventional and student-centered approaches. International Journal of Mathematics Education, 34(1), 22–39. https://doi.org/10.xxxx/ijme.2026.34.1.22
19. Müller, C., & Mildenberger, T. (2021). "Facilitating Flexible Learning by Replacing Classroom Time with an Online Learning Environment: A Systematic Review of Blended Learning in Higher Education." Educational Research Review, 34, 100394. https://doi.org/10.1016/j.edurev.2021.100394
20. Ochu, A. O. (2023). The confluence of attitudes towards mathematics and pedagogical practice: Evaluating the use of mathematical manipulatives. Mathematics Education Research Journal.
21. Sande, N., & Ndlovu, M. (2022). Grade 9 learners' structural and operational conceptions of the equal sign. Educational Studies in Mathematics.
22. Sison, J. (2025). Policies and reforms in mathematics education: Conventional teaching in exam-driven cultures.
23. Sun, Y., Nambiar, R., & Vidyasagaran, V. (2023). Gamifying Math Education Using Object Detection. arXiv preprint arXiv:2304.06270. https://arxiv.org/abs/2304.06270
24. Suydam, M. N., & Rieger, J. L. (1975). Mathematics in the Elementary School: The Use of Manipulatives and Activities.
25. **Taley, I.B., & Bukari, H.I. (2022).** Use of Manipulatives for Mathematics Teaching and Learning.https://www.researchgate.net/publication/376313200_CHAPTER_21_USE_OF_MANIPULATIVES_FOR_MATHEMATICS_TEACHING_AND_LEARNING
26. Zbiek, R. M., & Muir, M. (2011). Making Connections with Virtual Manipulatives: The Role of Dynamic Software in Teaching Algebra. The Mathematics Teacher, 104(9), 660-664.

https://www.researchgate.net/publication/363799334_A_Retrospective_of_TeachingTechnology_and Teacher_Education_During_the_COVID-19_Pandemic

27. Altun, M. (2023). The ongoing debate over teacher centered education and student centered education. International Journal of Social Sciences & Educational Studies, 10(1), 106–110. https://doi.org/10.23918/ijsses.v10i1p106
28. Baumgartner, E., Kaplan-Rakowski, R., Ferdig, R. E., Hartshorne, R., & Mouza, C. (Eds.). (2022). A retrospective of teaching, technology, and teacher education during the COVID-19 pandemic. Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/221522/
29. Dinsmoor, K. (2023). Math manipulatives. In Student-centered approaches in K–12 and higher education. EdTech Books. https://edtechbooks.org/student_centered/math_manipulatives
30. Greenstein, S., & Fernández, E. (2023). Learning mathematics with mathematical objects: Cases of teacher-made mathematical manipulatives. Contemporary Issues in Technology and Teacher Education, 23(1), 1–128. https://citejournal.org/volume-23/issue-1-23/objects-to-think-with/learning-mathematics-with-mathematical-objects-cases-of-teacher-made-mathematical-manipulatives
31. Hurst, C., & Linsell, C. (2020). Manipulatives and multiplicative thinking. European Journal of STEM Education, 5(1), Article 4. https://doi.org/10.20897/ejsteme/8375
32. Jaggernauth, S., Ramsawak-Jodha, N., Kamalodeen, V. J., Dedovets, Z., Barrow, D., & Figaro-Henry, S. (2020). Exploring gamification for reinforcing geometrical concepts and skills at the primary level in Trinidad: A mixed methods pilot study. Caribbean Curriculum, 26, 65–98. https://doi.org/10.47161/CC.2.u0017
33. Nash, E. (2023, April 19). Math manipulatives: A student-centered approach to teaching mathematics. Great Minds. https://greatminds.org/math/blog/eureka/math-manipulatives-a-student-centered-approach-to-teaching-mathematics
34. Tjandra, C. (2023). Effectiveness of using manipulatives in mathematics teaching in inclusive education programs in an elementary school. Dharmas Education Journal (DE_Journal), 4(1), 168–178. https://doi.org/10.56667/dejournal.v4i1.944