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Concrete Vs Virtual: Mathematical Game-Tools and its Effect on Students' Performance in Geometry

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A B S T R A C T

This study aims to fill this gap with empirical evidence that compares the concrete and virtual game-tools' effects on Grade 9 students' geometry performance. Findings from this study will help educators select the best set of tools for their students to better learn and engage with mathematics. Geometry is so important in developing critical thinking and spatial reasoning, yet, unfortunately, most of the students do not find much understanding of its concepts. Hence, this 2018 PISA report showing major gaps in Math's competency proved to be a call for new teaching strategies in math class. Mathematical game-tools, whether concrete or virtual tools, have facilitated this interactive approach towards increasing abstract concepts. However, few studies have compared the effectiveness of such tools to this date. This study aims to fill this gap with empirical evidence that compares the concrete and virtual game-tools' effects on Grade 9 students' geometry performance. Findings from this study will help educators select the best set of tools for their students to better learn and engage with mathematics.

Keywords: Concrete, Virtual Game tools,

1. Introduction

Geometry is a fundamental subject that has many applications in the real world. Studying geometry helps students develop abstract thinking and mathematical reasoning skills. They learn to identify patterns, make conjectures, and construct logical arguments to prove geometric theorems. However, insufficient emphasis on visual representations or inadequate instructional support in interpreting and constructing diagrams can hinder students' understanding and ability to apply geometric concepts effectively. Hence, geometry lessons that incorporate visualization often employ various methods to enhance understanding. Many educators find the manipulative technique particularly effective in teaching geometrical concepts. This approach enables students to grasp mathematical ideas from different angles, fostering a deeper conceptual understanding from basic to complex learning.

Specifically, there are two forms of manipulatives, concrete manipulatives, and virtual manipulatives. Concrete manipulatives for geometry are physical objects that can be used to teach and learn geometric concepts. However, virtual manipulatives are software applications that can be used to create interactive simulations of geometric shapes and problems. Both manipulatives help students to visualize and understand concepts in geometry in a more engaging and interactive way.

Utilization of mathematical game tools is one of the keys for students learning in geometry. Determining whether virtual or concrete is a crucial aspect of instructional design. Given that students use both forms of manipulatives, they still have a lack of knowledge on when and how to use it.

2. Theoretical Background

Geometry is a branch of mathematics that deals with the study of shapes, sizes, and positions of objects in space. It is an important subject that requires students to develop spatial reasoning skills. However, Filipino students were among the lowest performing groups of students among all the participating countries in the 2018 Program for International Student Assessment (PISA). In mathematics, less than 20% of students demonstrated the minimum proficiency level (Level 2), while more than 50% showed very low proficiency (below Level 1). Scoring below the lowest level of proficiency in the PISA, these Filipino students have been clearly left behind in terms of mathematics education; more than half of this age group of Filipino students have inadequate mathematical skill compared to their peers in other parts of the world. The poor performance in mathematics also varied in degree between the students in public and private schools, where the means were 343 and 395, respectively (Department of Education 2019). One approach to teaching geometry is to use game-tools, which can be either concrete or virtual manipulatives. Concrete manipulatives are physical objects that students can touch and move around, while virtual manipulatives are digital objects that students can manipulate on a computer or tablet.

According to Sari & Aydogdu, (2020) both concrete and virtual manipulatives develop the spatial capabilities of students. However, no evidence was produced with regard to one being better than the other. The study compared the effectiveness of virtual and concrete manipulatives in developing symmetry capabilities and found that both types of manipulatives were effective in developing students' symmetry capabilities. However, other studies have found no meaningful differences between the use of concrete and virtual tools in teaching mathematics.

3. Research Objectives

The primary aim of this study is to compare Concrete and Virtual Mathematical game-tools and their effect on students' performance in Grade 9 Geometry at South Greenville School.

4. Data and Methods

This study employed a Pre-designed tests covering geometry concepts will be used to gather quantitative data Moreover, observation, is used to identify subjective experiences of the students with regards to the mathematical game tools. The researchers will seek permission from the school head and the advisor of the section where the respondents will be taken. The preliminary phase in the study involved a pre-survey with the students at South Greenville School to identify their initial preference with mathematical game-tools as well as their learning experience in geometry. Then, once the researcher's data, the pre-test and post-test have been checked, revised and approved, the researchers will conduct a pre-test to all respondents of the study to assess baseline geometry knowledge. Next, the researcher will divide the class into 3 groups, Group A and B will receive instruction using either concrete or virtual game tools, while Group C will receive traditional geometry instruction. While the respondents are engaged in their work, the researchers will observe the process. Thus, after their work, the researchers will administer their post-test to all groups to assess changes in geometry knowledge. Finally, the researchers will conduct interviews and administer surveys to collect qualitative data.

5. Results

Table 1 presents the mean pre-test scores of students subjected to three different instructional approaches: traditional, concrete game-tools, and virtual game-tools.

Table 1 - Summary of Mean Pre-Test Score

	Deviation	**Interpretation**
Traditional	8.57	Satisfactory
Concrete	7	Satisfactory
Virtual	6	Marginal

Legend: (0-3 Unsatisfactory, 4-6 Marginal, 7-9 Satisfactory, 10-12 Very Good, 13-15 Outstanding)

The data in Table 1 presents the mean pre-test scores of students subjected to three different instructional approaches: traditional, concrete game-tools, and virtual game-tools. These findings align with the baseline data from a study by Ukdem and Çetin (2022), which examined the impact of interventions using concrete and virtual manipulatives on 3rd-grade students' understanding of fractions and motivation. Furthermore, a study by Bonea et al. (2021) compared the effectiveness of concrete and virtual manipulatives in teaching algebra to middle school students with disabilities. The research indicated that both types of manipulatives were effective in terms of accuracy, with no notable differences in student independence.

Table 2 summarizes the mean post-test scores for students subjected to three different instructional approaches: traditional, concrete game-tools, and virtual game-tools.

Table 2 – Summary of Mean Post Test Score

	Weighted Mean	**Standard Deviation**	**Score Interpretation**
Traditional	12.14	1.81	Very good
Concrete	10.57	2.07	Very good
Virtual	9.42	2.92	Satisfactory

Legend: (0-3 Unsatisfactory, 4-6 Marginal, 7-9 Satisfactory, 10-12 Very Good, 13-15 Outstanding)

Table 2 shows the mean post-test scores for students subjected to three different instructional approaches: traditional, concrete game-tools, and virtual game-tools.This finding aligns with research by Ukdem and Çetin (2022), who found that traditional teaching methods often serve as the most reliable approach for providing foundational knowledge in mathematics. This finding is consistent with the research of Ponte et al. (2023), who emphasized that concrete manipulatives are beneficial for promoting student understanding of mathematical concepts, especially in geometry, by providing a tactile

learning experience. This observation supports the findings of a study by Demetriou (2019), which found that while virtual manipulatives can be effective in increasing student performance, familiarity with the tools and instructional support are critical factors for success.

Table 3 shows the Difference in performance of approaches.

Table 3 - Difference in performance approaches.

Differences in Academic Progress					
	Critical Value	**Degrees of Freedom**	**Alpha Level**	**Computed T-Value**	**Interpretation**
Traditional Vs. Concrete	-2.447 – 2.447	12	0.05	1.07	No Significant Difference
Traditional Vs. Virtual	-2.447 – 2.447	12	0.05	1.52	No Significant Difference
Concrete Vs. Virtual	-2.447 – 2.447	12	0.05	0.84	No Significant Difference

Table 3 presents the t-test results for the difference in academic progress between three instructional approaches: traditional, concrete game-tools, and virtual game-tools.These findings are consistent with research by Ukdem and Çetin (2022), which demonstrated that both traditional and concrete manipulative-based approaches can effectively enhance students' understanding of mathematical concepts, with no significant advantage for one method over the other. This result may indicate that while concrete game-tools are a valuable resource, their effectiveness may depend on how they are integrated into the teaching process, and they may not provide a distinct advantage over traditional instruction when used alone. Research by Demetriou (2016) aligns with this result, indicating that while virtual manipulatives can enhance student engagement and learning, their effectiveness may vary depending on the context and how they are implemented in the classroom. This outcome could reflect the need for students to become more familiar with the technology or to receive more instructional support in using digital tools effectively.These findings are in line with Bonea et al. (2021), who noted that both concrete and virtual manipulatives can enhance students' understanding of mathematical concepts, with no significant differences between the two approaches. It is possible that factors such as students' familiarity with the tools, instructional strategies, and the level of engagement in the activities could have influenced the results.

6. Conclusions

Based on the findings presented in the results, the researchers conclude the following:

1. The mean pre-test scores showed that the traditional approach group had the highest average, followed by the concrete game-tools group, and lastly the virtual game-tools group. All three groups performed within the satisfactory to marginal range, indicating a moderate level of prior knowledge in geometry before any intervention was introduced.
2. Following the intervention, the post-test results revealed improved performance across all groups. Students who received instruction through the traditional approach and those who used concrete mathematical game-tools both attained a "very good" level of performance, while those who used virtual mathematical game-tools reached a "satisfactory" level. This suggests that all instructional strategies contributed positively to student learning, with notable improvements from their respective pre-test scores.
3. However, the statistical tests for significance showed that there was no significant difference in the post-test performance between the traditional approach and concrete game-tools, between the traditional approach and virtual game-tools, and between the concrete and virtual game-tools. As a result, all null hypotheses were accepted. These findings indicate that although mathematical game-tools—both concrete and virtual—positively influenced student performance in geometry, there was no statistically significant advantage of one approach over the others. Therefore, it can be concluded that the use of mathematical game-tools is an effective strategy in geometry instruction, yet their impact is comparable to that of the traditional teaching method

7. References

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