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Effect of Problem-Solving Enrichment Activities on Mathematics Achievement

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Abstract

This study investigated the effectiveness of using manipulative materials in enhancing problem-solving skills in Mathematics among Grade 2 pupils at Barugo II Central School for the school year 2018–2019. A quasi-experimental design was employed, with 40 pupils divided into an experimental group (n=20), which was taught using manipulative materials, and a control group (n=20), which received traditional instruction without manipulatives. A pre-test and post-test were administered to both groups to measure problem-solving achievement. Results revealed that pupils in the experimental group demonstrated significantly higher improvement in their problem-solving skills compared to those in the control group. The mean post-test score for the experimental group (20.05) was notably higher than that of the control group (15.90), and the statistical analysis confirmed that this difference was significant. Both groups showed improvement from pre-test to post-test, but the use of manipulative materials provided a more substantial gain in problem-solving achievement. The findings suggest that manipulative materials serve as an effective tool for enriching problem-solving skills in Mathematics. Based on the results, it is recommended that teachers integrate manipulative materials into their lessons and that enrichment activities be continuously developed and validated. The study also proposed an intervention scheme to further enhance problem-solving abilities in Mathematics, which future researchers could build upon.

Introduction

Education is a significant social investment, shaping individuals and impacting the development of a nation. In today's globally competitive environment, it is essential to equip students with the skills and knowledge to match their counterparts worldwide (Abulencia, 2015). In the Philippines, the implementation of the K to 12 curricula, starting in 2011, aimed to improve the quality of education and enhance the global competitiveness of Filipino learners (Rivera, 2017). The Department of Education (DepEd) anticipated that the K to 12 program would lead to better academic competencies and improved labor opportunities for graduates (Du, 2012). Moreover, the "No Filipino Child Left Behind Act of 2010" emphasized the state's responsibility to ensure accessible, quality education for all.

Mathematics, as a core subject in the curriculum, plays a critical role in everyday life and academic success (Gafoor & Kurukkan, 2015). However, many students face challenges in mastering it, often due to its perceived difficulty and the heavy course load (Ersozlu & Arslan, 2012). This difficulty underscores the need for innovative teaching strategies to enhance student learning and engagement.

Research has shown that using the Mother Tongue-Based Multilingual Education (MTB-MLE) approach helps students understand mathematical concepts better, especially when teaching is aligned with their home language (Hafiz & Farik, 2016). Studies also highlight that using engaging materials, like manipulative tools, fosters a positive learning environment, which can significantly improve problem-solving skills in Mathematics (Beecher & Sweeny, 2008).

In response to the ongoing quest for improved Mathematics instruction in the Philippines, this study investigates the role of manipulative materials as part of enrichment activities. The research explored whether these materials can enhance pupils' problem-solving achievements compared to traditional teaching methods that do not utilize such tools. The study seeks to determine if the use of manipulative materials significantly improves students' performance and understanding of mathematical problems, and whether this approach can be considered more effective than traditional, non-manipulative-based teaching methods. By focusing on engagement through practical and creative problem-solving methods, this research aims to offer a meaningful intervention to enhance the mathematical skills of Grade 2 pupils.

Methodology

Research Design

The study employed a quasi-experimental pre-test and post-test design with two groups: an experimental group taught with manipulative materials and a control group taught without them. This design allowed for the comparison of problem-solving achievements between the two groups, helping to determine the impact of manipulative materials on student learning outcomes.

Participants

The participants of this study were 40 Grade 2 pupils from Barugo II Central School during the school year 2018–2019. The sample was divided into two groups: Experimental Group (n = 20): This group received Mathematics instruction using manipulative materials. Control Group (n = 20): This group received traditional instruction without manipulative materials. Participants were selected using convenience sampling, based on the availability of pupils within the school and existing class assignments.

Instruments

A teacher-made problem-solving test was the primary instrument used in this study to assess students' problem-solving abilities in Mathematics. The test included mathematical problems appropriate for Grade 2, focusing on addition, subtraction, multiplication, division of whole numbers, and measurement concepts. The same test was administered as both a pre-test and post-test to gauge improvement in problem-solving skills.

The pre-test was **c**onducted before the intervention to establish baseline data on pupils' problem-solving skills. Post-test was conducted after the intervention to measure changes in performance. The validity of the test was established through expert review, and the reliability was confirmed through pilot testing with a small group of students.

Procedure

The study was conducted within 8-week period. Pre-test was administered to both the experimental and control groups with the same test to assess their initial problem-solving skills. The intervention follows when pupils in the experimental group were taught using manipulative materials such as counting blocks, geometric shapes, and number lines. It focused on using these tools to solve mathematical problems and facilitate hands-on learning experiences.

The control group received the same problem-solving lessons without the use of manipulative materials, relying instead on traditional instructional methods such as lectures and written exercises. Post-test was administered after the intervention; the same test was administered as a post-test to both groups to measure any changes in problem-solving performance.

Data Analysis

The collected data were analyzed using both descriptive and inferential statistics: Mean and Standard Deviation was used in the calculation the pre-test and post-test scores of both the experimental and control groups. t-Test for Independent Samples was used to compare the post-test scores between the experimental and control groups to determine if the difference in achievement was statistically significant. t-Test for Paired Samples was used to compare the pre-test and post-test scores within each group, assessing the improvement of problem-solving skills over the intervention period. The significance level was set at $p < 0.05$.

Ethical Considerations

Permission was obtained from the school administration, teachers, and the parents of the pupils before conducting the study. The identities of the pupils were kept confidential, and data were anonymized to protect their privacy. The study ensured that no harm was done to participants, and they were provided with equal learning opportunities throughout the research.

Results and Discussion

The mean pre-test scores of both groups were similar, with the experimental group scoring an average of 12.00

and the control group scoring an average of 12.15. This indicates that prior to the intervention, both groups had comparable problem-solving abilities. After the intervention, the experimental group, which was taught using manipulative materials, achieved a significantly higher mean post-test score of 20.05 compared to the control group's mean post-test score of 15.90. This suggests that the use of manipulative materials had a notable positive impact on the problem-solving abilities of the students in the experimental group.

The standard deviations (s.d.) of the pre-test scores were relatively close for both groups, with the experimental group having an s.d. of 2.49 and the control group having an s.d. of 2.39. In the post-test, the standard deviation for the experimental group increased slightly to 2.67, while the control group's standard deviation decreased to 1.74. The slight increase in variability for the experimental group's post-test scores could indicate a wider range of improvement among students, while the control group showed less variability in their post-test performance.

Table 1. Mean Pre-Test and Post-Test Scores of the Two Groups

Group	**Pretest**		**Posttest**	
	$\overline{\mathbf{X}}$	**s.d.**	$\overline{\mathbf{X}}$	**s.d.**
Experimental Group (n= 20)	12.00	2.49	20.05	2.67
Control Group (n= 20)	12.15	2.39	15.90	1.74

The results indicate that both teaching methods led to improvements in problem-solving skills, but the use of manipulative materials in the experimental group proved to be more effective. The significant increase in the mean scores from pre-test to post-test in the experimental group (12.00 to 20.05) compared to the control group (12.15 to 15.90) demonstrates the effectiveness of hands-on learning tools in enhancing mathematical understanding. The difference in post-test performance between the two groups suggests that manipulative materials helped students better conceptualize and solve mathematical problems, likely due to the tactile and visual reinforcement of mathematical concepts. This aligns with educational theories that emphasize active, experiential learning, particularly in young children.

These findings suggest that the integration of manipulative materials into mathematics instruction can be a highly effective intervention in improving problem-solving skills among Grade 2 pupils. The results support the hypothesis that hands-on activities facilitate a deeper understanding of abstract mathematical concepts, making them more accessible and engaging for young learners. Based on these findings, an intervention scheme focusing on the incorporation of manipulative materials in regular teaching practices could be recommended to further enhance problem-solving achievements.

The t-test results for both groups indicate a statistically significant difference in scores between the pre-test and post-test, with p-values less than 0.001. This suggests that the observed improvements in problem-solving scores are unlikely to have occurred by chance.

Table 2. Test of Difference between Pre-test and Post-test of the Experimental and the Control Group

Group	t	Df	p-value	Interpretation
Experimental Group (n = 20)	11. 86	19	<0.001	Significant
Control Group (n= 20)	11.60		<0.001	Significant

The t-value of 11.86 with 19 degrees of freedom and a p-value of <0.001 demonstrates a highly significant increase in the problem-solving skills of pupils who used manipulative materials. This strong result reinforces the effectiveness of hands-on learning tools in fostering mathematical understanding. Similarly, the control group also showed a significant t-value of 11.60 and a p-value of <0.001, indicating that traditional teaching methods without manipulatives also resulted in improved problem-solving skills. However, the magnitude of improvement was notably less than that of the experimental group.

The significant results from both groups highlight that while both teaching methods yielded improvements, the experimental group benefited to a greater extent from the use of manipulative materials. This discrepancy suggests that hands-on activities not only engage students but also provide concrete representations of abstract mathematical concepts, leading to deeper understanding and retention. The findings align with existing literature that emphasizes the importance of active learning environments in early mathematics education. The use of manipulative materials appears to enhance cognitive engagement, allowing pupils to explore and experiment with mathematical ideas in a way that promotes critical thinking and problem-solving skills.

In conclusion, the data support the hypothesis that incorporating manipulative materials in mathematics instruction significantly enhances problem-solving achievements among Grade 2 pupils. These findings suggest that educators should consider integrating such resources into their teaching strategies to improve mathematical outcomes for young learners. Future research could explore long-term effects of this approach and its applicability across different grade levels and mathematical concepts.

To further assess the effectiveness of manipulative materials on problem-solving skills, the mean gain scores for both the experimental and control groups were calculated. These gain scores represent the difference between the post-test and pre-test scores, providing a clear measure of improvement for each group. The results are summarized in Table 3.

Table 3. Mean Gain Scores of the Experimental and Control Groups

Group	Mean Gain Score	s.d.	Df	t	p- value	Interpretation
Experimental Group	8.05	3.03	27.21	5.721	<0.000	Significant
Control Group	3.75	1.45				

The experimental group showed a mean gain score of 8.05, while the control group had a mean gain score of 3.75. This substantial difference in gain scores indicates that pupils in the experimental group made significantly more progress in their problem-solving skills compared to those in the control group.

The standard deviation for the experimental group was 3.03, reflecting a moderate spread in the gain scores, while the control group's standard deviation was 1.45, indicating less variability in their performance. This suggests that the experimental group experienced a wider range of improvements, with some students benefiting significantly more from the use of manipulatives.

The t-value of 5.721 with degrees of freedom (Df) of 27.21 and a p-value of <0.000 further supports the conclusion that the difference in mean gain scores between the two groups is statistically significant. The low p-value indicates a high level of confidence that the observed differences are not due to random chance.

Intervention Scheme

Rationale

Proficiency in Mathematics is essential for everyday life and academic success. Students who struggle in mathematics, particularly in problem-solving, often need additional support beyond the standard classroom instruction. According to Ulichnie (2011), providing extra interventions is vital for students who perform below average in mathematics assessments. This study found that the use of *manipulative materials* significantly improved the problem-solving achievements of Grade 2 pupils, as shown by their post-test scores. Manipulative materials serve as an effective tool to help students better understand mathematical concepts by providing hands-on, visual learning experiences.

The study also revealed that both enrichment activities with and without the use of manipulatives are effective in enhancing problem-solving skills. However, the use of manipulatives proved to be more impactful, leading to the development of this *intervention scheme* designed specifically for Grade 2 pupils. The scheme aims to integrate manipulative materials into problem-solving activities, as aligned with the *K to 12 Curriculum Guide* for Mathematics, to strengthen students' foundational skills.

Objectives

After participating in a series of enrichment activities utilizing manipulative materials, Grade 2 pupils will be expected to:

1. Demonstrate an understanding of *addition **of*** whole numbers up to 1000, including the concept of money.
2. Apply addition of whole numbers up to 1000, including money, in both *mathematical problems* and *real-life situations***.**
3. Demonstrate an understanding of *subtraction* and *multiplication* of whole numbers up to 1000, including money.

4. Apply subtraction and multiplication in problem-solving and practical scenarios.
5. Demonstrate an understanding of *division* of whole numbers up to 1000, including money.
6. Show understanding of *standard measures* of length, mass, capacity, and area using square-tile units.
7. Apply standard measures of length, mass, capacity, and area in problem-solving tasks and daily life contexts.

Implementation Stage

The intervention will be implemented in the following phases:

1. **Preparation and Planning**

    - Identify the specific manipulative materials (e.g., blocks, counters, geometric shapes, bingo chips, paper blocks, ball in a bowl, pins, cubes, clips, paper strips, abacus, wooden pools and rubber on nails) that align with each objective.
    - Develop detailed lesson plans that integrate manipulatives into mathematical problem-solving activities.
    - Provide training for teachers to effectively use manipulative materials in the classroom.

2. **Classroom Instruction**

    - Conduct *weekly enrichment activities* using manipulative materials. Activities should focus on applying addition, subtraction, multiplication, and division concepts, as well as measurement tasks.
    - Use group work and individual activities to allow pupils to explore mathematical concepts through hands-on experience.
    - Encourage pupils to explain their problem-solving processes, fostering critical thinking.

3. **Monitoring and Assessment**

    - Use formative assessments, including observation, quizzes, and reflective journals, to monitor student progress.
    - Administer periodic post-tests to assess improvement in problem-solving skills and compare with baseline data.

4. **Parent and Community Involvement**

    - Provide simple take-home manipulative kits for students to practice with their families.
    - Organize workshops for parents to engage them in supporting their children’s learning at home.

5. **Evaluation**

   - Regularly evaluate the effectiveness of the intervention through feedback from teachers, pupils, and parents.
   - Adjust activities based on student progress and assessment results to ensure continuous improvement in problem-solving skills.

This intervention scheme provides a structured approach to enhancing problem-solving skills in Mathematics through the use of manipulative materials, ensuring that pupils not only understand mathematical concepts but also apply them effectively in real-life situations.

Conclusion

Pupils taught with manipulative materials achieved significantly higher problem-solving scores compared to those taught without such materials. The use of hands-on tools facilitated better understanding and application of mathematical concepts. Although the control group slightly outperformed the experimental group in the pretest, the experimental group surpassed the control group in the posttest. This highlights the effectiveness of manipulatives in enhancing problem-solving skills over time. Both methods, with and without manipulatives, were effective in improving problem-solving abilities. However, the use of manipulatives provided a greater boost in achievement.

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