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MOVE IT TO LEARN IT: Enhancing multiplication skills of Grade 3 Pupils using manipulatives

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ABSTRACT

Multiplication is a necessary skill that is needed to be learned yet, researchers found out that learners performance in this field is declining. With this, our research paper focuses on enhancing multiplication skills of Grade three pupils using manipulatives at San Rafael Integrated School. The respondents were subdivided into two groups, the experimental and the control group, which both comprises of 30 Grade three pupils. The instrument for collecting the data was through researcher's made pre-test and post-test questionnnaires. Results proved that before the utilization of manipulatives, both control and experimental group have not met the expected level of performance which posted 63.74and 63.34 grade percentage respectively. However, after the implementation of the intervention, the results posted a grade percentage of 76.14 for control group and 97.26 for the experimental which indicates an improvement in the multiplication skills of the Grade three learners most especially for the experimental group for the outstanding grade percentage. Overall, the results showed that using manipulatives such as square tiles and counters is effective in enhancing the multiplication skills of Grade three learners. Hence, the use of manipulatives in enhancing multiplication skills is recommended for a successful teaching and learning process.

Keywords: Counters, multiplication, multiplication skills, manipulatives, square tiles

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INTRODUCTION

Mathematics is one of the most significant disciplines, and it can be essential in every person's life (Velez et. al., 2023). It is a critical subject and a domain taught in elementary education. It provides students with fundamental knowledge and skills to organize the standards and ways of their lives (Ariyanti and Santoso, 2020). One of the fundamental mathematical operations is multiplication (Moreno and Susada, 2024). Thus, it is necessary to understand its concept and the when and how to multiply numbers to get the correct answer (Fuson, 2020).

However, based on the result presented by the Program for International Student Assessment (PISA), there is a decrease in the mean performance across OECD countries by 16 points from 496 (2018) to 480 (2022) in terms of mathematical proficiency which manifest that there is an ongoing challenge in the field of mathematics education due to the presented data of the learner's performance in mathematics (Mabena et al., 2021). In connection with this, Sönmez and Alptekin (2020) found out in their study that with the ongoing challenges in the field of mathematics, acquiring multiplication skills contributed significantly to the decrease in the mathematical performance of learners. Moreover, Rotem and Henik (2020) observed in their study where acquiring multiplication skills becomes increasingly challenging for students from the second-grade level to the fourth-grade grade in primary school, which significantly affects the learners' overall performance. Many researchers and studies had been done to address this problem on the low level of knowledge of basic mathematics but the problem persisted (Lee et al., 2024). With this, Song et al., (2023) suggested that repetition or computational drill does not lead to understanding; thus, the constructivist proposes using physical materials as a possible solution to address this academic problem. Using manipulatives can enhance students ' mathematical and conceptual understanding by viewing the problem constructively (Butcher, 2023). The concrete representation that the manipulatives offer provides students with concrete experience in building the abstract concepts of mathematics. Thus, Button (2021) emphasizes that the learners of the 21st century should be provided with all the accessible materials and strategies to ensure that they are equipped with basic knowledge in major disciplines, including the four (4) basic mathematical skills, which are addition, subtraction, multiplication and division skills.

In the Philippine setting, the Philippines faced challenges in mathematics education and ranked lowest in international assessments (Ignacio et al., 2022). As stipulated by the Programme for International Student Assessment (PISA) 2022 International Report, Filipino students' average score in mathematical literacy was 355 points, significantly lower than the Organization for Economic Cooperation and Development (OECD) average of 489 points, indicating a below Level 1 proficiency. The Philippines also scored 297 in math in the 2019 Trends in International Mathematics and Science Study (TIMSS) by the International Association for the Evaluation of Educational Achievement (Mullis et al., 2019). The presented statistical data just showed that the educational system of the Philippines is far more behind from other countries. It proves how unequipped and how weak is the foundation of the students in terms of mathematical knowledge and application specifically in multiplication which demands urgent yet effective strategies to address this problem. Thus, the utilization of strategies that are fit to the needs and interests of the pupils or the learners is very essential and very needed which can be the use of manipulatives such as square tiles and counters (Cardino and Dela Cruz, 2020).

Moreover, mathematics is believed to be the foundation of scientific-technological information, precisely dynamic in the economic growth of a nation which plays the most critical component relating to an individual's success (Dones et al., 2024), yet learners' achievement in mathematics has been declining over the years, as the results released by PISA and the Trends in International Mathematics and Science Study (TIMSS) (OECD, 2019; Mullis et al., 2019). Moreover, this problem is evident in the local setting, where learners find math the most complex subject. Sooknanan and Seemungal (2023) believes that pupils have a hard time understanding math concepts, especially those in the primary grades like Grades 1 to 3, as the foundation of knowledge in mathematics is not that strong because there is no face-to-face interaction between the teacher and the learner for more than two (2) years due to the COVID-19. With this, the teachers are exerting much effort in utilizing interventions such as manipulatives to fill the learning gap and build the foundation of learning in mathematics, especially in enhancing the multiplication skills of the learners (Aguhayon et al., 2023). This action research focused on exploring the effectiveness of manipulatives such as square tiles and counters as part of the learning materials in enhancing the skills of grade 3 learners in multiplication.

Cognitive Development theory of Jean Piaget is utilized specifically the concrete operational stage where Grade three learners belongs based on their age. This theory outlines how children progress as they develop cognitive abilities (Saracho, 2023). In this work, Piaget emphasizes the importance of active learning, where children construct knowledge through interaction with their environment (Waite-Stupiansky, 2022). The Concrete Operational Stage is particularly significant as it marks the beginning of logical or operational thought in children ages 7-11 (McLeod, 2024). Children can think logically about concrete events in this stage but struggle with abstract or hypothetical concepts (Zhang, 2023). In connection with this, manipulatives are utilized to present and enable children to develop the skills of thinking logically about concrete events, which play a vital role in enhancing learning during the concrete operational stage (Ahmad, 2024). Children can manipulate and interact with these materials by providing physical objects like square tiles and popsicle sticks to understand mathematical concepts concretely (Kajander, 2023). These hands-on experiences help solidify their understanding of multiplication by visually representing abstract mathematical operations (Murtazaev and Shukrulloev, 2024). In addition, Ahmad et al., (2024) emphasized that in the concrete operational stage, manipulatives are essential to meet all the characteristics and needed cognitive development, including the development of problem-solving skills as well as the understanding of the principles of conservation, reversibility, classification, seriation, and decentering.

There are many strategies implemented and interventions made to enhance multiplication skills of the learners but all of it focused on diagrams and teacher centered approaches (Kling, 2023). Our research focused on enhancing the multiplication skills of Grade three learners through the usage of manipulatives where there multi-sensory senses are activity and to test whether physical manipulation can build a stronger foundation knowledge towards mathematics and in multiplication, in specifics.

The study focused mainly on assessing whether the use of manipulatives such as square tiles and counters have an impact in enhancing multiplication skills of Grade three learners through comparing the pre-test and post-test of both control and experimental group. Futhermore, the findings of this study will benefit learners and educators as becomes a basis to integrate manipuatives to have an effective and successful teaching. For the parents, this will helps them to povide sufficient aid to ensure their child's development in solving multiplication. And most importantly, to the school administrators, to see the effectiveness of manipulatives which can significantly affect the overall educational environment.

MATERIALS AND METHODS

Research locale and duration

The study was conducted at San Rafael Integrated School, Purok Proper, Barangay San Rafael, Cateel, Davao Oriental. With the increasing number of learners and the demographical location of the school which is accessible to the researchers, the San Rafael Integrated School is chosen as the place to conduct the study. The Grade three classrooms were found in Building 4, on the right side of Building 3, and on the left of the ABS-CBN Foundation Building (Building 5). Additionally, the intervention or data gathering from the respondents was completed within one month, and each group was given 2-3 weekly meetings.

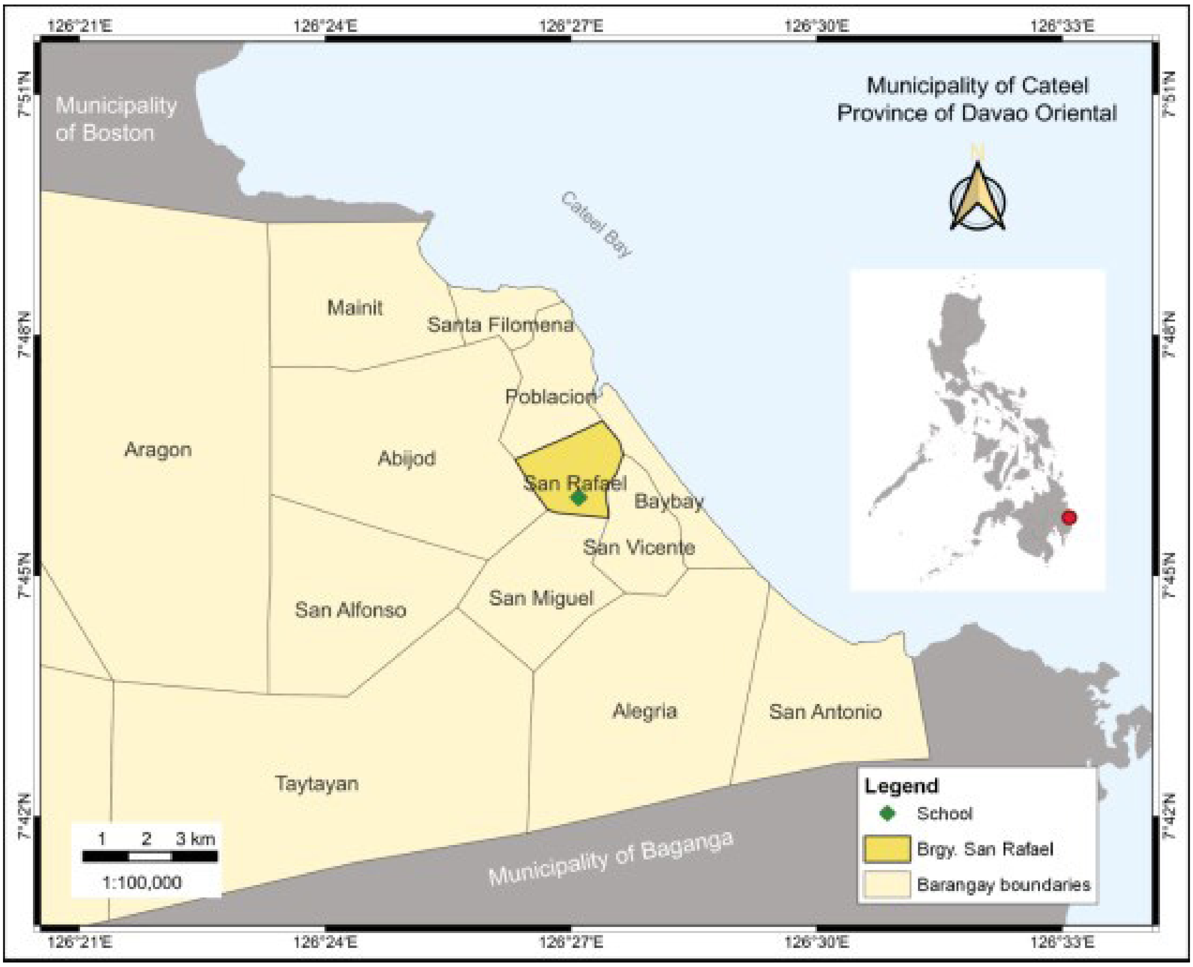

Figure 1. Map of Cateel, Davao Oriental, highlighting San Rafael Integrated School.

Data collection

The researcher formulated several procedural steps to achieve the goal of this study. First, seeking ethical clearance from the Research Ethics Office (REO). Next, the school Principal of San Rafael Integrated School received a letter requesting permission, and they talked with the advisers of the two selected sections and the pupils, confirming their approval to participate in the study's data collection. After the approval, the researcher created a self-made questionnaire and was responsible for the reproduction for distribution. The questionnaire underwent a validity test before administering the research questionnaires. The questionnaire was validated by the 3 experts using an evaluation tool, and those experts are master teachers teaching mathematics at the elementary level. The questionnaire was valid as the result posted by the Aiken-V is 0.85. The Aiken-V standard criteria state that the item is valid if V-Aiken ≥ 0.75, so the analysis results can state that the items in the questionnaire are categorized to measure the respondents' knowledge in terms of multiplication. As the utilized research instrument was research-made, the questionnaire underwent a pilot testing study to measure its reliability. The researchers conducted a pilot test at Santa Filomena Elementary School and Modesto T. Veroy, Sr. Integrated School. Moreover, the expert thoroughly analyzed the pupils' responses to each item, and the Kuder-Richardson (KR) 20 coefficient value was utilized to test the reliability of the research instrument. The scores for KR-20 range from 0 to 1, where 0 is no reliability, and 1 is perfect reliability. The closer the score is to 1, the more reliable the test. Thus, to make the research instrument reliable, the KR-20 coefficient value should be closer to 1, making the questionnaire a reliable tool in assessing the multiplication skills of Grade three pupils in San Rafael Integrated School, by which our results posted 0.61. then, the researcher administered a pre-test questionnaire to the control and experimental group.

The respondents of this study were the Grade three pupils of San Rafael Integrated School. They were selected through a complete enumeration sampling technique, meaning the pupils in selected sections were all the study respondents. Moreover, the respondents were grouped into experimental and control groups by tossing a coin. The two groups comprised a total number of pupils in one class every weekday.

The researcher spent two weeks in the two sections and was involved in eight sessions each week. The control group received a traditional teaching approach, whereas the experimental group received instructions using manipulatives as an intervention. After the conduct of the instruction both for experimental and control group, the researcher administered the post-test at the end of the instructions in the control and experimental groups. The post-test questionnaire was collected and tabulated, and all data were given to the assigned statistician for reliable interpretation of the intervention's results.

Data collection for experimental group

For the experimental group, pre-test was the first step undertaken. After the pre-test was conducted for this research, the use of manipulatives such as counters and square tiles to enhance the multiplication skills of the learners was implemented. Manipulatives were properly chosen based on the learning competency. We utilized square tiles, and counter including popsicle sticks, pencils, stones in explaining and demonstrating the process of multiplication to come up with the product. After the required number of sessions for the implementation of the intervention, post-test was conducted which was collected and gathered by the researchers.

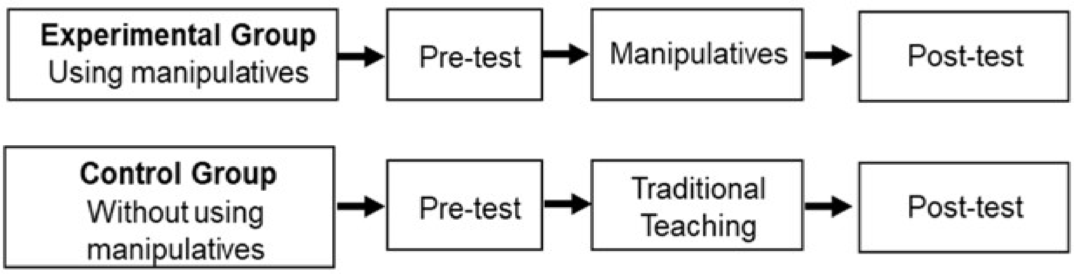

Figure 2. Steps in data gathering.

Data analysis

The study used mean and independent sample *t*-tests as statistical tools.

Mean. This statistical tool was used to determine the average score of both experimental and control group. This helps determine (1) the level of pre-test scores and (3) the post-test scores of the respondents from the two groups. In other words, mean as a tool is appropriately utilized to answer objectives 1 and 3.

Table 1. K to 12 grading system.

Grading scale	Interpretation
90-100	Outstanding
85-89	Very satisfactory
80-84	Satisfactory
75-79	Fairly satisfactory
Below 75	Did not meet expectations

Independent sample *t*-test. This statistical tool determined (2) the significant difference in pre-test results between the controlled and experimental groups and (4) the significant difference in post-test scores between the controlled and experimental groups that can be used to determine whether there is a significcant difference between the experimental group and control group.In other words, the tool mentioned earlier was utilized to answer objectives 2 and 4.

Table 2. Table of interpretation.

p-value	Interpretation
Less than 0.05	There is a significant difference
0.05 or more	There is no significant difference

Table 3 shows that the control and experimental groups' total score, mean, and grade percentage fall short of the expected passing score. The control group's grade percentage was 65.94. In contrast, the experimental group posted 65.48, which signifies that the learners did not meet the expected level of proficiency in mathematics, specifically in multiplication.

Table 3. Level of pre-test scores between the control and experimental groups.

Group	Total score	SD	Mean	Percentage	Remarks
Control	25	2.78	7.97	65.94	Did not meet expectations
Experimental	25	3.45	7.74	65.48	Did not meet expectations

Table 4 shows that the pre-test scores for the control and experimental groups do not differ significantly, with mean scores of 7.97 for the control group and a similar score for the experimental group. The *t*-value of 0.323 and *p*-value of 0.748 indicate no significant difference between the two groups' initial mathematics proficiency levels. Both groups started with a comparable understanding of mathematics, specifically in multiplication, which still requires significant improvement.

Table 4. Mean comparison between pre-test scores of control and experimental group.

Group	Mean	SD	*t*-value	*p*-value	Interpretation
Control	7.97	2.78	0.323	0.748	Pre-test scores between the two groups do not differ significantly.
Experimental	7.74	3.45			

Table 5 shows that the control and experimental groups progressed in their multiplication performance. However, the study results indicated a significant difference between the control and experimental groups in terms of their multiplication skills. The experimental group, which was exposed to manipulatives, outperformed the control group, achieving a mean score of 23.63 and a grade percentage of 97.26%, which was considered outstanding. In contrast, the control group had a mean score of 13.07 and a grade percentage of 76.14%, which was considered fairly satisfactory.

Table 5. Level of post-test scores between the control and experimental groups.

Group	Total score	SD	Mean	Percentage	Interpretation
Control	25	1.36	13.07	76.14	Fairly satisfactory
Experimental	25	0.85	23.63	97.26	Outstanding

Table 6 results indicate a significant difference in post-test scores between the control and experimental groups, with the latter showing a higher mean score of 23.63 compared to 13.07 for the control group. The intervention applied to the experimental group significantly improved their performance. The lower standard deviation in the experimental group (0.85) versus the control group (1.36) further indicates more consistent performance among those who received the intervention.

Table 6. Mean comparison between post-test scores of control and experimental group.

Group	Mean	SD	*f*-value	*p*-value	Interpretation
Control	13.07	1.36	-36.029	0.000	Post-test scores between the two groups differ significantly
Experimental	23. 63	0.85			

DISCUSSIONS

Level of Pre-Test scores between the control and experimental groups

The data presented in Table 3 indicates that both the control and experimental groups failed to achieve the expected level of proficiency in mathematics, particularly in multiplication, as evidenced by their grade percentages of 65.94 and 65.48, respectively. It agrees with the broader trends observed by the Program for International Student Assessment (PISA), which reported a decline in mathematical proficiency across OECD countries from 496 in 2018 to 480 in 2022 (Mabena et al., 2021). The challenge of mastering multiplication skills, as highlighted by Sönmez and Alptekin (2020), significantly contributes to this decline.

Factors influencing these outcomes include student-related issues such as mathematics anxiety, low interest, and inadequate foundational knowledge (Newman-Naami, 2023). Additionally, cognitive variables like working memory capacity and flexibility play crucial roles in learning multiplication, as De Santana et al., (2022) and Rahayuningsih et al., (2020) noted. These cognitive aspects must be addressed to enhance students' learning strategies effectively.

Parental support also significantly impacts mathematical performance, as Cui et al., (2023) pointed out, suggesting that the level of interest and positive parental reinforcement can enhance learners' performance. Moreover, Assem et al., (2023) emphasized the importance of teacher expertise, attitude, and teaching methods. Effective instructional strategies, such as using manipulatives to represent mathematical concepts (Laski et al., 2023) and contextualizing multiplication in real-world scenarios (Smith and Morgan, 2016; Drljević et al., 2022), can improve student engagement and understanding.

Thus, the findings from Table 3 reflect a broader systemic issue in mathematics education, underscoring the need for comprehensive approaches that address all aspects of the learner's life, including cognitive factors, student attitudes, parental involvement, and effective teaching methodologies to enhance multiplication skills and overall mathematical proficiency.

Mean comparison between pre-test scores of control and experimental group

Table 4 shows that the pre-test scores for the control and experimental groups do not differ significantly, with mean scores of 7.97 for the control group and a similar score for the experimental group. The *t*-value of 0.323 and *p*-value of 0.748 indicate no significant difference between the two groups' initial mathematics proficiency levels. Both groups started with a comparable understanding of mathematics, specifically in multiplication, which still requires significant improvement.

This outcome aligns with the inherent difficulties in learning multiplication due to its cognitive demands and the abstract nature of the concept (Siegler and Lortie-Forgues, 2015). Factors contributing to this low proficiency of the two groups include the quality of instructional methods, where direct and explicit teaching often proves more effective than discovery-based approaches (Ramaswamy and Lackey, 2023). Additionally, the need for frequent practice and use of concrete manipulatives is well-supported, although the transition to abstract understanding remains critical (Fe and Pisaras, 2020). The lack of significant difference between the control and experimental groups suggests that the intervention may have been insignificant. It highlights the necessity for evidence-based instructional strategies, such as explicit instruction and varied practice opportunities tailored to individual studentneeds (Mitchell and Sutherland, 2020). Furthermore, socioeconomic factors and parental involvement also play a crucial role, as students from lower socioeconomic backgrounds often face additional challenges accessing educational resources (Ugwuegbulem, 2018). Addressing these multifaceted issues is essential for improving multiplication proficiency among learners.

Post-test scores of the control and experimental group

The findings presented in Table 5 underscore the critical role of multiplication in mathematical education. According to Körtesi et al., (2020), multiplication skills are fundamental for mathematical development. Larsson (2016) emphasizes that mastering multiplication is essential for basic arithmetic and higher-level math concepts. It aligns with the observed outcomes, where students who engaged with manipulatives demonstrated superior multiplication skills, indicating a deeper understanding and mastery of the subject.

The significant improvement in the experimental group can be attributed to the use of manipulatives, which address several factors affecting multiplication skills. Resnick (2020) highlight that a solid understanding of arithmetic concepts is foundational for effective multiplication. Manipulatives help in building this foundation by providing concrete experiences that enhance comprehension.

Acharya (2017) points out that mathematics anxiety, low interest, and poor concentration can hinder learning. Using manipulatives likely mitigated these issues by making learning more engaging and less intimidating. Alloway and Copello (2013) emphasize the importance of working memory in solving multiplication problems. Manipulatives support this by enabling students to visualize and manipulate numerical information, thus improving their working memory capacity.

The success of the experimental group demonstrates the effectiveness of the correlation of the concrete-operational phase of Jean Piaget's Cognitive Development. According to Piaget, children in the Concrete Operational Stage (typically ages 7 to 11) develop logical thinking skills about concrete objects and events (Butterworth, 2022). This stage is characterized by the ability to perform operations on tangible objects and understand logical relationships. Piaget emphasized that children learn best through hands-on activities and direct manipulation of objects (Blake and Pope, 2015). Using manipulatives, such as square tiles and counters, provides concrete representations of multiplication concepts, which is crucial for students in this developmental stage.

By engaging with manipulatives, students can physically manipulate and explore mathematical ideas, which helps them to internalize and understand abstract concepts (Goldin, 2020). The improved performance of the experimental group suggests that these hands-on experiences enabled students to build a stronger conceptual understanding of multiplication. This finding is consistent with the idea that children at the Concrete Operational Stage benefit significantly from interactive and tactile learning experiences (Byrne, 2019).

Moreover, manipulatives help students to practice logical reasoning and problem-solving skills. As Piaget noted, the Concrete Operational Stage involves the development of logical thinking about concrete situations (Ghazi et al., 2016). Using manipulatives, students can see andtouch the quantities they are working with, making abstract multiplication operations more understandable. This hands-on approach allows them to construct their understanding of mathematical concepts, reinforcing their cognitive development (Carbonneau et al., 2013).

The lower standard deviation in the experimental group's scores (0.85 compared to 1.36 in the control group) indicates more consistent performance, suggesting that manipulatives also help level the learning field among students with varying abilities (Paas et al., 2014). This consistency is critical as it shows that the intervention was effective across many learners, enhancing their multiplication skills regardless of their initial proficiency levels.

The difference in post-test scores between control and experimental group

The findings presented in table 6 shows several factors that can elucidate the causes behind this notable difference. Firstly, the importance of using manipulatives in teaching multiplication, as emphasized by Larbi and Mavis (2016), Larsson (2016), and Sealander et al., (2012), suggests that the hands-on learning experiences provided to the Experimental group likely facilitated a deeper understanding of the multiplication concepts. By engaging with concrete materials such as counters and square tiles, learners may have developed a more robust foundation of knowledge, as supported by Larbi and Mavis (2016).

Additionally, manipulatives help translate abstract mathematical concepts into concrete forms, making them more accessible and understandable (Larbi and Mavis, 2016; Sarama and Clements, 2016). By engaging with physical objects, students can better grasp the process of multiplication as repeated addition (Larsson, 2016), which is critical for developing a foundational understanding of more complex mathematical operations.

Also, this notable improvement in the experimental group underscores the effectiveness of manipulatives in enhancing multiplication skills. It aligns with Piaget's theory of cognitive development, specifically the Concrete Operational Stage, which posits that children learn best through hands-on, tangible experiences (Butterworth, 2022). According to Piaget, children develop logical thinking skills about concrete objects and events during the Concrete Operational Stage (typically ages 7 to 11). Using manipulatives provides concrete representations of multiplication, making abstract concepts more accessible and understandable for learners at this developmental stage (Blake and Pope, 2015).

The experimental group's higher mean score and lower standard deviation suggest that manipulatives improved overall performance and resulted in more consistent student learning outcomes. It indicates that manipulatives help level the playing field, better supporting students of varying abilities in understanding multiplication (Paas et al., 2014). The hands-on manipulation of objects helps students construct their understanding, reinforcing their cognitive development and enabling them to internalize mathematical concepts more effectively (Goldin, 2020).

Moreover, the significant emphasis on active learning and problem-solving, as highlighted by Lugosi and Uribe (2022) suggests that the intervention fostered critical thinking skills and effective reasoning, essential for mastering mathematical concepts.

Implication to mathematics education

The study's results have significant implications for mathematics education. Firstly, identifying a substantial learning gap in multiplication skills among Grade three learners underscores the need for heightened focus on this particular area within mathematics education. This recognition highlights the importance of prioritizing interventions and instructional strategies tailored to address multiplication proficiency (Alsaleh, 2020; Larsson, 2016).

Secondly, the notable success of the experimental group, which received the intervention involving the utilization of manipulatives such as square tiles and counters, in achieving higher post-test scores and reaching an outstanding level of attainment compared to the control group suggests the efficacy of incorporating hands-on learning experiences in teaching multiplication. This finding underscores the value of experiential learning approaches, emphasizing that engaging students in tangible, interactive activities can effectively bridge learning gaps and enhance understanding (Larbi and Mavis, 2016; Sarama and Clements, 2016).

Lastly, the indication that the traditional instructional methods employed in the control group may have failed to effectively address the challenges in acquiring multiplication skills among Grade 3 learners underscores the importance of embracing innovative teaching methodologies in mathematics education. It highlights the necessity of exploring alternative approaches and techniques to ensure students' comprehensive and effective learning experiences, particularly in areas where traditional methods may prove insufficient (Oliveira et al., 2021; Bahadir, 2017).

CONCLUSION

The findings revealed significant insights into the effectiveness of using manipulatives, such as square tiles and counters, in enhancing multiplication skills among Grade three students. Initially, both the control group and the experimental group showed similar performance levels in multiplication, with pre-test scores of 65.94 and 65.48, respectively, indicating that neither group met the expected performance standards. The lack of significant difference in pre-test scores, with means of 7.97 and 7.74 and a *p*-value of 0.748, confirms that both groups were on an equal footing before the intervention. However, following the introduction of manipulatives, the experimental group demonstrated a notable improvement in their post-test scores, achieving a grade percentage of 97.26 compared to 76.14 in the control group. This improvement is reflected in the significant difference in post-test scores, where the experimental group had a mean score of 23.63, markedly higher than the control group's mean score of 13.07.

These findings are crucial as they highlight the positive impact of manipulatives on learning outcomes in multiplication. The substantial enhancement observed in the experimental group's performance underscores the value of incorporating tactile, visual learning tools into mathematics instruction. For mathematics education, this suggests that manipulatives can play a pivotal role in improving student understanding and engagement, particularly in foundational areas like multiplication.

Based on these results, it is recommended that educators integrate manipulatives into their teaching practices to support and enhance students' multiplication skills. Professional development should focus on effective strategies for using these tools in the classroom. Additionally, further research is needed to explore the long-term benefits of manipulatives and their effectiveness across various mathematical concepts and student demographics. This will provide a more comprehensive understanding of how to optimize teaching practices and improve educational outcomes.

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