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# The effectiveness of Lego manipulatives in solving area problems involving squares and rectangles for Grade 3 students

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## ABSTRACT

Problem-solving skills, specifically in solving routine and non-routine problems involving areas of squares and rectangles, are foundational to various mathematical concepts; however, learners consistently find these concepts challenging to master. This study at San Rafael Integrated School (2023-2024) investigated the impact of using Lego kits to teach Grade 3 students how to solve routine and non-routine problems involving the areas of squares and rectangles. Using a quasi-experimental methodology, two groups of 30 students each were compared: a control group taught with traditional methods and an experimental group taught using Legos. Pre-test results indicated that neither the control nor the experimental group met the expectations set by the K to 12 grading system, with 7.41 and 9.12 scores. Although both groups exhibited similar initial proficiency levels, the notable difference in pre-test scores can be attributed to various factors (including the students' value for mathematics). However, despite their appreciation for the subject, many still struggle with fundamental skills and concepts; this may have influenced their performance in the pre-test. Post-test results (however) revealed a significant improvement in the experimental group's performance, with a mean score of 25.28 compared to the control group's 16.07. The findings demonstrate the superior efficacy of the Legos as a manipulative kit over traditional methods in solving routine and non-routine problems involving areas of squares and rectangles. Thus, teachers may incorporate Legos as manipulative kits early in the school year to provide a visual and tactile learning experience that helps students build a concrete understanding of mathematical operations.

*Keywords:* Legos, manipulative kits, non-routine problems, routine problems

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## INTRODUCTION

In mathematics education, developing problem-solving skills is crucial for academic success (Santos-Trigo, 2020). However, many students face difficulties in tackling mathematical problems, often due to a lack of interest in the subject; some even find math to be overly complicated (Lai et al., 2015). Despite numerous studies on problem-solving abilities (Bahar and Aksut, 2020; Gupta et al., 2015), students continue to struggle-particularly as they transition from basic calculations to more complex problem-solving methods in third grade (Boaler et al., 2022).

Research by Hendriana et al. (2018) indicates that improving problem-solving skills can help address these challenges, which are essential for a solid understanding of math. This is especially alarming given that only 30% of third graders can effectively solve complex mathematical problems (Smith et al., 2015), highlighting a significant gap in mathematical skills.

To clarify, routine problems are those that can be solved using familiar procedures or algorithms, typically involving the straightforward application of well-practiced mathematical rules (Van Harpen and Presmeg, 2013). For instance, finding the area of a square using a known formula is a routine problem. On the other hand, non-routine problems require higher-order thinking, creativity, and the ability to consider various strategies, as they often do not have a clear, predetermined solution path (Byrne et al., 2023). These problems may involve applying knowledge to new situations, such as figuring out how to maximize the area of a rectangle with limited resources.

The distinction between these types of problems is crucial to this study, which explores whether manipulatives-specifically lego kits-can improve students' abilities to tackle both routine and non-routine problems involving squares and rectangles (Arslan and Yazgan, 2015). Research has shown that traditional teaching methods often fall short in helping students master these important skills. In contrast, manipulative kits have been shown to boost performance; for example, a study by Lanante (2019) found that teachers in the Central Philippines who used manipulative kits with Grade 2 students saw significant improvements in their problem-solving skills.

This research stems from a recognized gap: despite students valuing mathematics highly, they often struggle with basic problem-solving skills when taught through traditional methods (English and Gainsburg, 2015). This prompted an exploration into whether the use of manipulatives could improve not only students' understanding but also their engagement, especially in tackling both routine and non-routine problems involving squares and rectangles (Divine,2013). Previous studies have shown that manipulatives-like base-ten blocks, Unifix cubes, and legos-can enhance critical thinking, deepen understanding, and support differentiated instruction (Laski et al., 2015; McDonough, 2016). Additionally, manipulatives cater to various learning styles, giving students the opportunity to explore, compare, and solidify mathematical concepts in a hands-on and engaging manner (Güneş and Genç, 2021). This study aims to address this gap by examining how manipulative kits, specifically designed to align with students' learning needs, can foster a deeper grasp of mathematical concepts-particularly those related to squares and rectangles-and improve problem-solving abilities (Angco and Angco, 2024).

## METHODOLOGY

### Description of the study area

The study was conducted at San Rafael Integrated School at Purok Proper, Barangay San Rafael, Cateel, Davao Oriental. The school has a total area of 43,228 square meters. The school's population was 866; 835 were learners, and 31 were school personnel. The Grade 3 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 expected to be completed within one month, and each group was given two weekly meetings.

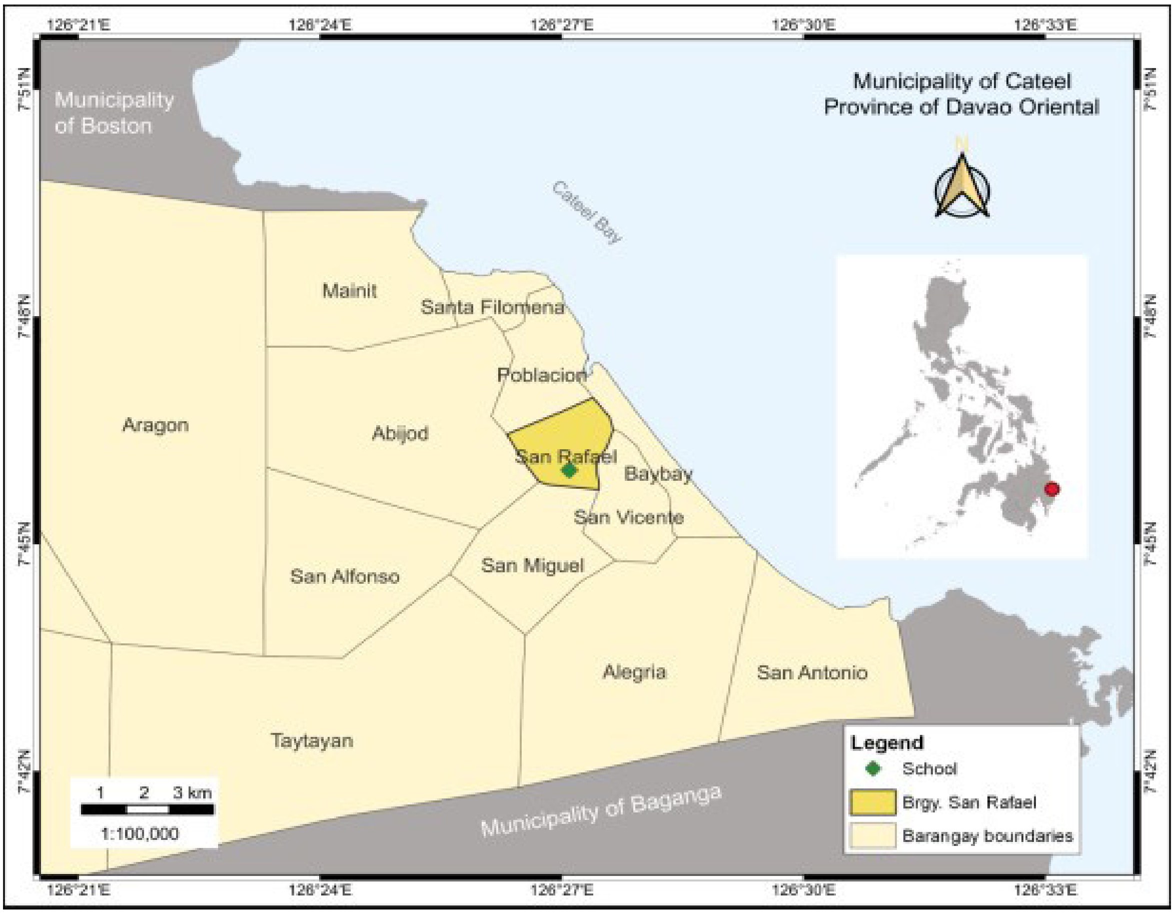


**Figure 1.** Satellite image of San Rafael Integrated School.

**Data collection**

This study utilized a quantitative research design, specifically a quasi-experimental design. It is actually termed a quasi-experimental design because the groups were formed without true random assignment.

Although the randomized design is preferred, ethical, logistical, and practical issues with it made that approach difficult for the purposes of this study. A pre-existing class structure provided a categorization base to avoid interfering with student learning experiences because random assignment would have been both impossible and unethical. Therefore, a quasi-experimental design was used for the two groups. For all that the study still tests the effect of an intervention upon specific groups, where the respondents are divided into two (2) groups: a control group and an experimental group. According to (Tyler, 2012), a quasi-experimental design is used as a research design to test the effectiveness of an intervention, which in this study is the use of manipulatives. This research design subdivides the respondents into two (2) groups. The experimental group will be the subject of utilizing the intervention, which is the manipulatives to enhance the problem-solving skills of Grade 3 learners. In contrast, the other group, which is the control group, will be subjected to traditional teaching (Kablan, 2014). The respondents of this study were the Grade 3 students of San Rafael Integrated School. They were chosen through a


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quasi-experimental sampling and grouped as experimental and control groups using a tossed coin. In addition, the two groups comprised of 30 students each.

The researcher began by obtaining ethical clearance to ensure that the study complied with all necessary guidelines and standards. Following this, permission was sought from the school head and classroom advisers to conduct the study with the students. Once permission was granted, the researcher administered a pre-test to the respondents. Attached to this pre-test was a consent form, which explained the purpose of the study and requested permission for the respondents to participate in the study. Respondents were instructed to complete the consent form, including their name (which was optional) and signature, before proceeding with the test. After completing the pre-test, the researcher collected the questionnaires and expressed gratitude to the participants for their cooperation.

For the control group, the researcher utilized traditional teaching methods to instruct students on solving routine and non-routine problems involving the areas of squares and rectangles. In contrast, the experimental group was taught using Legos as manipulative kits to enhance their understanding of the same concepts. Following the instructional period, a post-test was administered to both groups. After the respondents completed the post-test, the researcher collected the questionnaires once more. The collected data was then handed over to a research statistician to ensure a thorough and accurate analysis of the results.

**Research instrument**

This study developed a researcher-made pre-test and post-test questionnaire instrument to measure respondents' learning. The test, consisting of 30 multiple-choice items, focused on the learning competency: solve routine and non-routine problems involving areas of squares and rectangles, "M3ME-IVf46". The specific learning objectives were for learners to identify and describe the steps in solving routine problems involving areas of squares and rectangles, solve routine and non-routine problems involving areas of squares and rectangles, find areas of squares and rectangles, and formulate "facts" involving areas of squares and rectangles in real-world scenarios.

The instrument underwent a content validity test using Aiken's V coefficient, based on expert ratings regarding measurement outcomes, essentiality to learning outcomes, and quality of questions (Sireci and Bond, 2014). The content validity result was highly favorable, with an Aiken's V coefficient of 0.91. Reliability was assessed using Cronbach's alpha, yielding a coefficient of 0.86, indicating high reliability. Thus,the instrument used in the study was both valid and reliable.

**Data analysis**

In order to analyze and arrive at a trustworthy and accurate interpretation of the gathered data from the pre-test and post-test questionnaire responses from the experimental and control groups, the K-12 Department of Education grading system was employed. Mean scores and independent sample *t*-tests were used to determine and analyze the findings.

**Mean.** This statistical instrument was used to determine (1) the average of pre-test solving routine and none routine problems involving areas of squares and rectangles test score achievement between control group and experimental group and (2) the average of post-test solving routine and non-routine problems involving areas of squares and rectangles test score achievement between control group and experimental group. The result was interpreted based on the grading scale with its corresponding interpretation:

**Table 1.** DepEd K-12 grading system.

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

**Independent sample *t*-test.** This statistical tool determined the significant difference in pre-test results between the controlled and experimental groups and the significant difference in post-test scores between the controlled and experimental groups. In other words, the tool mentioned earlier was utilized to answer objectives 2 and 4.

## RESULTS

**Table 2.** Level of pre-test scores between the control and experimental groups.

| Group | Total score | Standard deviation | Mean | Grade percentage | Remarks |
|---|---|---|---|---|---|
| Control | 30 | 2.60 | 7.41 | 62.35 | Did not meet expectations |
| Experimental | 30 | 2.68 | 9.12 | 65.20 | Did not meet expectations |

Table 2 reveals that the pre-test scores of the participants in the control group averaged 7.41, with a corresponding grade percentage of 62.35. The K–12 Grading Scale interpretation indicates that students struggled to perform according to the expected standard. On the contrary, the experimental group performed similarly to the control group in that it did not reach the expected standards, as seen by its lower mean average of 9.12 and grade percentage of 65.20.

**Table 3.** Mean comparison between pre-test scores of control and experimental group.

| Type of test | Mean | Standard deviation | *t*-value | *p*-value | Interpretation |
|---|---|---|---|---|---|
| Control | 7.41 | 2.60 | -2.540 | 0.014 | Pre-test scores between the two groups differ significantly. |
| Experimental | 9.21 | 2.68 | | | |

Table 3 reveals a significant difference in pre-test scores between the experimental and control groups, as evidenced by a corresponding *p*-value of 0.014 and a *t*-value of -2.540. There were initial differences in the students' knowledge levels before any instructional conversations. The pre-test results showed that the control group got a low mean score of 7.41. It means that students obtained in the pre-test a low-grade percentage, and the experimental got 9.21.

**Table 4.** Level of pre-test scores between the control and experimental groups.

| Group | Total score | Standard deviation | Mean | Grade percentage | Remarks |
|---|---|---|---|---|---|
| Control | 30 | 1.67 | 16.07 | 76.78 | Fairly satisfactory |
| Experimental | 30 | 3.48 | 25.28 | 92.13 | Outstanding |

According to table 4, the participants in the control group had a mean post-test score of 16.07, corresponding to a grade percentage of 76.78. This indicates that students accomplished the expected fairly satisfactory remarks, according to the K–12

Grading Scale. The experimental group, on the other hand, had a higher grade percentage of 92.13, along with an average score of 25.28. This implies that the third-grade students who had the intervention and were instructed to utilize Lego kits as manipulatives throughout the discussion got outstanding marks. The results show that this intervention better solves routine and non-routine problems involving squares and rectangles.

**Table 5.** Mean comparison between post-test scores of control and experimental group.

| Type of test | Mean | Standard deviation | *t*-value | *p*-value | Interpretation |
|---|---|---|---|---|---|
| Control<br>Experimental | 16.07<br>25.28 | 1.67<br>3.48 | 163.06 | 0.000 | Post-test scores between the two groups differ significantly. |

Table 5 reveals a statistically significant difference (p-value of 0.000) between the experimental and control groups. Table 5 shows that the experimental group received a higher mean score of 25.28 on the post-test than 16.07 for the control group. In the pre-test, the interval between the experimental and control groups was just 1.71, whereas in the post-test, this interval increased significantly to 9.21.

## DISCUSSION

### Pre-test scores of the control and experimental group

Mathematics anxiety, characterized by negative feelings toward the mathematics learning process and a lack of understanding of the subject matter, can contribute to low pre-test scores (Acharya, 2017). Research suggests that students need help making sense of problems, which is critical since solving mathematical problems involving squares and rectangles is foundational for more advanced mathematical understanding (Singh et al., 2020). However, learning outcomes may improve significantly with varied instructional approaches that make learning meaningful, as children succeed best through diverse and engaging methods (Bergman, 2019). Studies reveal that students need help translating word problems into mathematical phrases and often need help with carelessness, lack of comprehension, interchanging values, and unfamiliar terms (Sultan, 2014). Participation in problem-solving activities enhances critical and independent thinking (Anawati et al., 2020).

Moreover, insufficient foundational knowledge can make it challenging for students to grasp more complex concepts; gaps in understanding basic arithmetic can cascade into difficulties with higher-level math. Socio-cultural factors, such as stereotypes about mathematics being inherently complex or gender biases suggesting that boys are better at math than girls, can also negatively impact students' attitudes and performance (Hall, 2013). Lastly, inconsistent or lack of timely feedback from educators can leave students unsure about their understanding and progress, exacerbating their struggles also, inconsistent or lack of timely feedback from educators can leave students unsure about their understanding and progress, exacerbating their struggles, further contributing to difficulties in mathematics (Brunyé et al., 2013).

### The difference of pre-test scores between control and experimental group

It is evident that individuals attribute significant importance to mathematics; however, numerous students face challenges regarding their mathematical competencies, underscoring the urgent need for reforms in pedagogical methods (Golafshani, 2023). Many students persist in lagging behind in mathematics and gradually lose interest, which can ultimately lead to disengagement and, in some cases, a complete abandonment of the subject (Yeh et al., 2019). Without students' interest, their engagement and focus on the material diminishes considerably. According to Tambychik et al. (2014), students necessitate a diverse array of math skills and strategies to efficiently tackle problems. To address these issues, it is imperative to implement effective teaching methods that cater to the intellectual needs of students, because inadequate instructional strategies can exacerbate their difficulties (Nam, 2022). In this context, examining the disparity in pre-test scores between the control and experimental groups was crucial to e stablish baseline equivalence. This process ensured that both groups commenced with comparable proficiency levels, allowing any variations in post-test scores to be ascribed to the intervention itself, rather than to pre-existing disparities.

By establishing baseline equivalence, a just comparison can be made concerning how various teaching strategies affect students' mathematical performance; this is crucial because it eliminates the influence of initial differences in knowledge and skills (Richards et al. 2018). However, one must consider that the context of the study might also play a role in the outcomes. Although the methodology appears sound, there could be other factors at play, but focusing on baseline equivalence provides a clearer picture.

**Post-test scores of the control and experimental group**

Hands-on learning can assist students in internalizing mathematical concepts and boosting their motivation to learn (Alisa et al., 2023). In this case, it suggests that the respondents benefit from focused teaching and strategies that incorporate manipulative kits. It focuses on the effects of using legos as manipulative kits in mathematics instruction on children's learning and transfer. As stated by Marley et al. (2015), students and teachers can configure and manipulate the objects, whether concrete or virtual, to reflect the ideas at the heart of a lesson. Manipulative kits such as legos were instrumental in helping students comprehend the various concepts taught. Kurz and Kokic (2014) noted that manipulatives were often used to make the math games more fun, but students were more beneficial in helping the students solve the problems.

Manipulative materials are valuable tools that help students of any academic level understand mathematics well, and they are not just for students of low academic ability but are also suitable for students of high academic ability (McIntosh, 2013). Additionally, using concrete legos as manipulative kits in mathematics instruction produces a small-to-medium-sized effect on student learning compared to instruction with no concrete materials (Carbonneau et al., 2015). Thus, manipulation also encourages active learning and problem-solving, which can improve students' critical thinking skills and independent learning (Tjandra, 2023). The results by Hurst and Linsell (2020) that manipulatives enhance the understanding and reasoning of math are seen to align with Linsell (2020) and Lange's (2021) results that manipulatives enhance student learning. Similarly, this is with the experiential learning theory from Dewey, where tools such as Legos should encourage active engagement and deeper understanding of the concept, hence being in favor of Grade 3 students.

**The difference of post-test scores between control and experimental group**

The result shows in Table 5 suggests that using legos as manipulative kits improves third-grade learners' capacity to solve problems involving squares and rectangles more effectively than using usual teaching methods. This analysis provides more evidence to support the theory that the experimental group


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experienced the more significant performance boost that was seen. This shows clearly the advantages of using manipulative kits like Legos in math education. This comparison allows for a clear assessment of the impact of the intervention on student achievement (Pontual et al., 2018).

This approach fosters student involvement and facilitates comprehension development through practical manipulation. Therefore, Hurst and Linsell (2020) found that math assessment scores and conceptual understanding of math skills improved when the students used the Legos as manipulative kits. It was also revealed in the study of Cautivo (2022) that using legos stimulates learners' interest, increases their mathematical skills, and develops concentration and perseverance skills while learning about cause and effect and creatively analyzing and solving problems. Thus, these findings also support the result that Legos, as manipulative kits, have the potential to help concrete abstract ideas, help students solve problems, and make math lessons more exciting and fun (Spring, 2015). Therefore, most research demonstrates an improvement in mathematics achievement following using manipulative kits such as legos as an intervention strategy (Yanzick, 2017). According to Disbudak (2019), using manipulatives has improved students' conceptual knowledge, active learning, support for various learning styles, problem-solving abilities, and post-test scores.

It can aid in students' learning, as demonstrated by the post-test results, which showed that students' scores improved after utilizing the intervention (Syamsuddin, 2018). In order to visualize what is happening in a problem, modeling is helpful for students (Schutz and Rainey, 2019). Manipulatives are widely used in mathematics education to support students' conceptual understanding of the content (Kowiyah, 2021). When students see these possibilities visually, they realize there are various ways to reach a result and that there is more than one possibility; students efficiently encode the addition process in their minds (Disseler, 2017).

In addition, a study (Bjorklund, 2013) concluded that using Legos as manipulative kits helps pupils comprehend abstract mathematical ideas and perform better. Students who used manipulatives in math class performed better than their peers who did not use manipulatives (Bouck et al., 2021). A similar study involving Grades 3 and 4 students concluded that manipulatives reinforced math concepts and increased average test scores. Using manipulatives has recently improved mathematics learning (Björklund, 2014). According to Golafshani (2014), using Legos as manipulative kits during instruction for solving problems related to squares and rectangles led to improved student performance in post-tests, indicating enhanced learning outcomes. This approach enhances cognitive engagement and allows students to physically and psychologically interact with mathematical concepts over the long term. Aligning with Dewey's theory, which emphasizes learning through meaningful experiences, using manipulatives like Legos promotes active learning, problem-solving skills, and deeper conceptual understanding in mathematics education.

## CONCLUSION

The results revealed that the pre-test scores for both the control and experimental groups did not meet the expected standard based on the K-12 grading system, indicating initial variations in students' knowledge levels before class discussions. However, the post-test results showed a clear distinction: the control group still failed to meet the expected standards, while the experimental group, taught using Legos as manipulative kits, achieved significantly higher average scores. This significant difference between the post-test scores suggests that using Legos as manipulatives enhances third-grade students' ability to solve routine and non-routine problems involving the areas of squares and rectangles more effectively than traditional teaching methods.

Manipulatives in mathematics education, as highlighted by Liggett (2017), are valuable tools that enhance student learning by providing tangible objects that make abstract concepts more accessible. Utilizing Legos as manipulatives exemplifies this, aligning with John Dewey's Experiential Learning Theory by promoting active participation, hands-on exploration, and problem-solving skills. This approach not only aids in understanding and retaining mathematical concepts but also fosters critical thinking, collaboration, and engagement Legos contribute to a positive classroom environment and help build a strong mathematical foundation.

Incorporating Legos as manipulatives in education can significantly enhance students' understanding of mathematical concepts, particularly in solving routine and non-routine problems involving areas of squares and rectangles. Schools might consider implementing bridging programs and providing ongoing teacher training to ensure effective integration of Legos into lesson plans, promoting hands-on learning.

## RECOMMENDATIONS

1. Teachers may incorporate legos as manipulative kits early in the school year to help students build a concrete understanding of these mathematical operations. Using Legos can provide a visual and tactile learning experience and improve problem-solving abilities.
2. Schools may implement bridging programs that utilize Legos as manipulatives to support students who need additional help understanding how to solve routi roblems involving areas of squares and rectangles.
3. Teachers may receive ongoing training on effectively integrating legos as manipulative kits into their lessons. Lesson plans should include activities that use legos as manipulative kits to help students visualize and understand the processes of solving routine and non-routine problems, ensuring a hands-on learning experience.
4. Regular evaluations of teaching methods and student performance may be conducted to refine and improve the use of these manipulatives. Creating a classroom environment emphasizing hands-on learning with legos can reinforce understanding and retention of problem-solving skills.

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