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The Impact of the Project-Based Learning (PjBL) Model on Students' Numeracy Skills at SD 48/1 Penerokan

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ABSTRACT

Numeracy remains a critical competency for primary school students; however, classroom practices at SD 48 still tend to emphasize teacher-centered instruction, memorization, and worksheet-based activities. These practices limit students' opportunities to apply mathematical reasoning, estimation, measurement, data interpretation, representation, and contextual problem solving in meaningful situations. This study aimed to examine the impact of the Project-Based Learning (PjBL) model on students' numeracy skills at SD 48. A quantitative approach with a post-test only control group design was employed. The sample consisted of 50 fifth-grade students, comprising 25 students in the experimental group taught through PjBL and 25 students in the control group taught through conventional instruction. Data were collected using a numeracy test and classroom observation. The instrument was validated through expert judgment and analyzed using descriptive statistics, the Shapiro–Wilk normality test, Levene's homogeneity test, an independent samples t-test, and effect size analysis. The results showed that the experimental group obtained an average posttest score of 86.00, with a standard deviation of 8,66. The data were normally distributed and homogeneous. The independent samples t-test indicated a significant difference between groups, $t(48) = -9,73$, $p < 0.01$, with a large effect size based on Cohen's $d = -2.75$. These findings indicate that PjBL supports numeracy development by engaging students in contextual, collaborative, and inquiry-based learning activities. The study concludes that PjBL has a significant and substantial impact on students' numeracy skills and can be used as an effective instructional alternative in primary mathematics learning.

Keywords: *Project-Based Learning, Numeracy Skills, Primary Education*

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INTRODUCTION

In the contemporary era of globalized, technologically driven, and data-intensive societies, the mastery of numeracy skills has been universally recognized as a foundational cognitive competency required by primary school students to successfully navigate the multifaceted challenges of 21st-century environments (OECD, 2023). International educational benchmarks and transnational assessments, such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS), have consistently argued that numeracy extends far beyond the traditional, rigid boundaries of routine arithmetic calculations and mechanical memorization of algorithms. Instead, true numeracy encompasses higher-order cognitive abilities that enable individuals to flexibly interpret, critically analyze, evaluate, and apply mathematical and scientific concepts to solve authentic, ill-structured problems across diverse real-world contexts (OECD, 2023).

Similarly, the TIMSS 2023 mathematics framework emphasizes students' ability to apply mathematical knowledge, select appropriate operations and strategies, represent data, and solve problems situated in meaningful contexts (Mullis et al., 2023). These perspectives indicate that numeracy should be understood as a multidimensional construct involving mathematical reasoning, representation, interpretation, measurement, estimation, and the application of quantitative information in authentic situations.

The development of numeracy in primary education is closely related to the need for contextual, active, and socially meaningful learning. Numeracy is related to mathematics, yet it is not identical to the mastery of mathematical content alone. It involves the ability to use mathematical knowledge flexibly across school and everyday contexts, including interpreting information, making judgments, and solving problems that require quantitative reasoning (Goos & Access, 2022). Therefore, numeracy learning should not be limited to procedural exercises. It should provide opportunities for students to investigate concrete phenomena, manipulate learning materials, discuss ideas with peers, interpret data, and connect mathematical symbols with observable realities. Such an orientation is consistent with project-based and socio-constructivist learning principles, which position students as active participants in constructing knowledge through inquiry, collaboration, and real-life problem solving (Lazić et al., 2021).

This theoretical position is particularly relevant because numeracy difficulties in primary schools are often associated with decontextualized instruction. When mathematics is presented mainly through teacher explanation, rote memorization, textbook reading, and worksheet-based drills, students may learn how to perform operations without understanding why those operations matter or how they can be used in real-life situations. This condition may reduce students' engagement and confidence in mathematics learning. Previous research has shown that mathematics anxiety may already appear among school-aged children and can interfere with students' mathematical development (Balt et al., 2022). A meta-analysis by (Barroso et al., 2017) also found a negative relationship between mathematics anxiety and mathematics achievement. These findings suggest that learning strategies should not only improve students' procedural competence, but also create meaningful, engaging, and confidence-building mathematical experiences.

Preliminary observations and baseline assessments conducted at SD 48 indicate a gap between the expected orientation of numeracy learning and actual classroom practice. Instruction remains largely teacher-centered, with dominant reliance on explanation, memorization, textbook

reading, and worksheet-based exercises. As a result, students tend to perceive mathematics as abstract, difficult, and disconnected from scientific or everyday contexts. This condition is reflected in low classroom engagement, limited student participation during problem-solving activities, and unsatisfactory numeracy performance in initial school-based assessments. These findings suggest the need for an instructional intervention that can reposition students as active learners and provide them with opportunities to apply numerical reasoning in meaningful learning situations.

Project-Based Learning (PjBL) offers a relevant pedagogical alternative for addressing this problem. PjBL is a student-centered instructional model that involves students in exploring meaningful questions, conducting inquiry, collaborating with peers, applying disciplinary concepts, and producing learning products based on the investigated problem. In elementary mathematics education, project-based instruction allows students to connect mathematical concepts with real-life situations and provides opportunities for them to learn through active participation and contextual problem solving (Lazić et al., 2021). The stages of PjBL, such as identifying a driving question, planning a project, conducting inquiry, collecting and analyzing information, producing a final product, and presenting the results, are closely aligned with the development of numeracy skills.

The characteristics of PjBL support numeracy development because project activities require students to measure objects, estimate quantities, compare data, classify information, calculate results, construct tables or diagrams, interpret findings, and communicate conclusions. Through these activities, students are encouraged to understand numbers as tools for making sense of real-world phenomena rather than as isolated symbols in textbooks. Therefore, PjBL has the potential to strengthen not only students' mathematical procedures, but also their reasoning, interpretation, representation, and contextual application of numeracy.

Empirical evidence supports the relevance of PjBL in improving students' learning outcomes. (Zhang & Ma, 2023) meta-analysis found that PjBL has a positive effect on students' academic achievement, affective outcomes, and thinking skills compared with traditional instruction. In elementary mathematics education, (Lazić et al., 2021) reported that students who learned through project-based instruction achieved better mathematics outcomes than those who learned through conventional instruction. In the Indonesian context, (Asmi et al., 2022) found that PjBL has been associated with improvements in mathematics learning, including achievement, motivation, conceptual understanding, creative thinking, critical thinking, and higher-order thinking skills. Recent studies in Indonesian elementary school contexts also indicate that PjBL can support literacy and numeracy development by connecting learning activities with authentic and contextual experiences (Rahayuningsih et al., 2025; Abdullah, 2026).

Nevertheless, a more specific research gap remains. Rahayuningsih et al (2025)examined PjBL as part of AKM implementation through a qualitative case study that emphasized school practices, teacher collaboration, and contextual numeracy learning. Meanwhile, Panjaitan et al (2024) used classroom action research to examine students' numeracy improvement across several learning cycles in a single elementary school. In contrast, the present study specifically examines the measurable effect of PjBL on elementary students' numeracy skills by focusing on their ability to use numbers, interpret quantitative information, and solve contextual problems. Thus, the novelty of this study lies in its focused assessment of numeracy as an independent learning outcome rather than as part of broader mathematics achievement, combined literacy-numeracy outcomes, or a descriptive account of PjBL implementation.

Studies that specifically examine the impact of PjBL on multidimensional numeracy skills in a particular public primary school context remain limited. This gap is important because numeracy is not a single skill, but a multidimensional construct involving mathematical reasoning, measurement, estimation, data interpretation, representation, and contextual problem solving. Therefore, a more focused investigation is needed to determine how PjBL affects students' numeracy skills in the specific classroom context of SD 48.

Based on the identified theoretical, empirical, and contextual gaps, this study aims to examine the impact of the Project-Based Learning (PjBL) model on students' numeracy skills at SD 48. The findings are expected to contribute to the development of evidence-based numeracy instruction in primary education by demonstrating how project-based activities can be used to connect mathematical concepts with real-life problems. At the practical level, this study provides teachers with an instructional reference for designing contextual, collaborative, and student-centered numeracy learning. At the policy and curriculum level, the study supports ongoing efforts to strengthen foundational learning, particularly literacy and numeracy, as essential competencies for improving the quality of primary education (UNICEF, 2023)

METHODS

This study employed a quantitative approach with a post-test only control group design to examine the impact of the Project-Based Learning (PjBL) model on students' numeracy skills. Referring to (Sugiyono, 2021) this design is used to test the effect of a treatment by comparing the outcomes of an experimental group and a control group. The population consisted of all fifth-grade students at SD 48. The researchers selected 50 students through simple random sampling and divided them into two groups. The experimental group consisted of 25 students who received instruction through Project-Based Learning, while the control group consisted of 25 students who received conventional instruction. After the intervention, both groups completed a posttest to measure their numeracy skills.

The numeracy test was developed based on indicators of number understanding, basic arithmetic operations, estimation, data interpretation, representation, and contextual problem solving. The instrument was validated through expert judgment involving two validators, who assessed content relevance, language clarity, difficulty level, and alignment with numeracy indicators. Data were analyzed using descriptive and inferential statistics. Descriptive statistics included mean, standard deviation, and standard error. Before hypothesis testing, the Shapiro–Wilk test was used to examine data normality, while Levene's Test was used to examine the homogeneity of variance. An independent samples t-test was then applied to determine whether there was a significant difference in numeracy skills between the experimental and control groups. Effect size was calculated using Cohen's d, Hedges' correction, and Glass's delta to determine the magnitude of the PjBL impact. Ethical procedures were maintained by obtaining school permission, informing participants about the research purpose, and ensuring data confidentiality.

RESULTS

This study examined the impact of the Project-Based Learning (PjBL) model on students' numeracy skills at SD 48. Data were obtained from the posttest scores of students after the

implementation of the learning intervention. The analysis included descriptive statistics, normality testing, homogeneity testing, independent samples t-test, and effect size calculation.

Table 1. Descriptive Statistics of Posttest Scores

Test	Average Score	Standard Deviation	Standard Error
Posttest control	67,20	12,423	3,65
Posttest experiment	86,00	8,66	1,73

Table 1 presents the posttest results of the control and experimental groups. The control group obtained an average score of 67.20, with a standard deviation of 12.423 and a standard error of 3.65. Meanwhile, the experimental group achieved a higher average score of 86.00, with a standard deviation of 8.66 and a standard error of 1.73. The difference in the average scores between the two groups was 18.80 points. This finding indicates that students taught using the Project-Based Learning model demonstrated better numeracy performance than students taught using conventional instruction. In addition, the lower standard deviation in the experimental group shows that students' scores were more consistent and less dispersed. The lower standard error also indicates that the experimental group's mean score provided a more stable estimate of students' posttest performance. Before hypothesis testing was conducted, assumption tests were performed. The homogeneity of variance was examined using Levene's Test, as presented in Table 2.

Table 2. Levene Homogenity

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Mark	Based on Mean	.925	1	48	.339
	Based on Median	.706	1	48	.403
	Based on Median and with adjusted df	.706	1	75.258	.404
	Based on trimmed mean	.889	1	48	.349

The results of Levene's Test show that the significance value based on the mean was 0.339. Since this value was greater than 0.05, the variance between the experimental and control groups was homogeneous. Therefore, the independent samples t-test could be interpreted using the equal variances assumed row. The normality test was conducted using the Shapiro–Wilk test. The result is presented in Table 3.

Table 3. Shapiro-Wilk Normality Test Results

Test	Shapiro-Wilk Statistic	Standard Deviation	Standard Error
Posttest control	0,92	0,06	Normal
Posttest control	0,73	0,06	Normal

Table 3 shows that the Shapiro–Wilk significance value was 0.06. Since the value was greater than 0.05, the posttest data were normally distributed. Thus, the data fulfilled the normality assumption required for parametric statistical analysis.

After the assumptions of normality and homogeneity were met, an independent samples t-test was conducted to examine whether there was a significant difference in numeracy skills between students taught using the Project-Based Learning model and those taught using conventional instruction.

Table 4. Independent Samples t-test Result

Test	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval
Equal variances assumed	-9,73	48	< 0,01	-22,80	-27,51 to -18,09
Equal variances not assumed	-9,73	47,59	< 0,01	-22,80	-27,51 to -18,09

Table 4 indicates that the independent samples t-test produced a significance value of less than 0.01. This result shows that there was a statistically significant difference in numeracy skills between the two groups. The mean difference of -22.80 indicates a substantial difference between the experimental and control groups. The negative sign reflects the order of group comparison in the statistical output and does not indicate a negative intervention effect. Substantively, the result demonstrates that students who learned through the Project-Based Learning model achieved higher numeracy performance than students who received conventional instruction. To determine the magnitude of the intervention effect, effect size analysis was conducted using Cohen's d, Hedges' correction, and Glass's delta.

Table 5. Effect Size Result

Effect Size	Standardizer	Point Estimate	95% CI Lower	95% CI Upper	Category
Cohen's d	8,28	-2,75	-3,53	-1,97	Large
Hedges' correction	8,42	-2,71	-3,47	-1,93	Large
Glass's delta	8,66	-2,63	-3,55	-1,70	Large

Table 5 presents the effect size estimates for the difference in numeracy skills between the experimental and control groups. Cohen's d was −2.75, Hedges' correction was −2.71, and Glass's delta was −2.63. All estimates indicate a large practical effect based on their absolute values. The negative signs only reflect the direction of the group comparison and do not indicate a negative effect of Project-Based Learning. These results show that the difference between the two groups was not only statistically significant but also substantial in practical terms. Therefore, the implementation of Project-Based Learning had a strong effect on students' numeracy skills compared with conventional instruction.Therefore, the implementation of the Project-Based Learning model had a large impact on students' numeracy skills.

The findings of this study indicate that the Project-Based Learning model had a significant impact on students' numeracy skills at SD 48. The posttest average score of 86.00 suggests that

students demonstrated strong numeracy performance after participating in project-based learning activities. This finding is consistent with the current understanding of numeracy as a multidimensional competency that involves reasoning, representation, estimation, interpretation, and problem solving in real-life contexts. The (OECD, 2023) emphasizes that mathematical literacy requires students to formulate, employ, and interpret mathematics in authentic situations, while the TIMSS 2023 framework also positions mathematical achievement as involving knowing, applying, and reasoning rather than procedural calculation alone (Mullis et al., 2023).

DISCUSSION

The significant result of the independent samples t-test indicates that the difference between students who learned through PjBL and those who learned through conventional instruction was not random. This finding supports the argument that project-based learning can provide students with more meaningful opportunities to apply mathematical ideas in contextual situations. In PjBL, students are encouraged to identify problems, collect information, measure, estimate, classify data, interpret findings, and communicate results. These activities are closely related to the development of numeracy because students do not only calculate answers, but also use numbers as tools for reasoning and decision-making. This aligns with (Goos & Access, 2022) explanation that numeracy should be developed across meaningful curricular contexts rather than reduced to basic arithmetic practice.

The large effect size found in this study strengthens the statistical result by showing that the impact of PjBL was not only significant but also practically meaningful. The Cohen's d value of -2.75, Hedges' correction of -2.71, and Glass's delta of -2.63 all indicate a large effect. In educational research, this suggests that the learning model contributed substantially to students' numeracy performance. This result is in line with (Zhang & Ma, 2023) meta-analysis, which found that PjBL significantly improves students' learning outcomes, including academic achievement, affective outcomes, and thinking skills. Similarly Lazić et al (2021) reported that project-based instruction had a significant positive effect on elementary students' mathematics achievement compared with conventional learning.

The improvement in numeracy skills may be explained by the active and contextual nature of PjBL. Unlike conventional instruction, which often emphasizes teacher explanation and worksheet completion, PjBL allows students to engage directly with learning tasks that require mathematical reasoning. Through project activities, students can connect numerical concepts with concrete experiences, such as measuring objects, comparing quantities, organizing information into tables, interpreting data, and presenting conclusions. This type of learning environment supports deeper understanding because students are required to apply mathematical concepts rather than merely memorize procedures. Recent studies in Indonesian contexts also indicate that PjBL supports mathematics learning by improving achievement, motivation, conceptual understanding, critical thinking, creative thinking, and higher-order thinking skills (Asmi et al., 2022; Rahayuningsih et al., 2025)

The effectiveness of PjBL in this study is also supported by recent findings showing that project-based instructional materials and project-oriented classroom activities can strengthen students' literacy and numeracy development.Sumarno et al (2024) found that bilingual project-based materials significantly supported elementary students' literacy and numeracy achievement

by integrating learning activities with contextual and engaging tasks. Similarly, (Panjaitan et al., 2024) reported that the implementation of PjBL improved elementary students' numeracy skills through active project cycles that increased engagement, mathematical understanding, and real-world problem application. Furthermore, (Supianti et al., 2025) demonstrated that STEAM-oriented PjBL contributed to students' mathematical literacy and character development, particularly through collaborative and interdisciplinary learning. These studies reinforce the present finding that PjBL can serve as an effective instructional model for improving students' numeracy skills when learning is designed around authentic, collaborative, and problem-based activities.

The findings also suggest that PjBL may help reduce the gap between mathematics as an abstract school subject and numeracy as a practical life skill. Numeracy requires students to make sense of quantitative information in different situations, including daily life, science learning, and problem-solving activities. Therefore, the use of projects can make mathematics more relevant and accessible for primary school students. This is particularly important in elementary education, where students need concrete experiences to build foundational understanding. (UNICEF, 2023) emphasizes that foundational learning, including basic literacy, numeracy, and socio-emotional skills, is essential for children's long-term academic development and participation in society.

Another important implication of the result is related to student engagement and confidence. Project-based activities may create a learning atmosphere in which students are more actively involved, collaborate with peers, and experience mathematics as a meaningful tool. Such conditions can support students who previously perceived mathematics as difficult or disconnected from everyday life. Balt et al (2022) argue that mathematics anxiety among school children needs to be addressed through learning approaches that reduce negative emotional experiences and support confidence in mathematical tasks. In this sense, PjBL may contribute not only to cognitive improvement but also to more positive student participation in numeracy learning (Balt et al., 2022).

The result of this study also corresponds with recent findings on PjBL implementation in primary education. Asmi & al (2022) reported that PjBL contributed to the improvement of literacy and numeracy skills among fifth-grade elementary students. Rahayuningsih et al (2025) also found that project-based learning can support numeracy development in Indonesian primary schools by connecting learning activities with authentic contexts. These findings support the present study by showing that PjBL is relevant not only in general mathematics learning but also in efforts to strengthen numeracy as a foundational competence. However, the findings should be interpreted within the scope of the research design. Since this study used a post-test only control group design, the analysis focused on comparing students' numeracy performance after the intervention. Although the statistical results showed a significant difference and a large effect size, future studies may use a pretest-posttest control group design to examine students' initial equivalence and learning gain more comprehensively. Future research may also involve a larger sample, multiple schools, and longer intervention periods to strengthen the generalizability of the findings. Overall, the findings demonstrate that the Project-Based Learning model has a significant and large impact on students' numeracy skills at SD 48. The model supports numeracy development by providing contextual, collaborative, inquiry-based, and student-centered learning experiences. Therefore, PjBL can be considered an effective instructional alternative for improving primary students' numeracy skills, particularly when teachers aim to connect mathematical concepts with real-life problem solving

CONCLUSIONS

This study concludes that Project-Based Learning significantly improves the numeracy skills of fifth-grade students at SD 48. Students who participated in PjBL demonstrated better numeracy performance than those who received conventional instruction. The findings also indicate that PjBL produced a substantial practical effect on students' ability to use mathematical concepts in meaningful contexts. Through collaborative and inquiry-based project activities, students practiced measurement, estimation, calculation, data interpretation, mathematical representation, and contextual problem solving. Therefore, PjBL supports students in understanding mathematics not only as a set of procedures but also as a practical tool for addressing problems in everyday life.

The findings provide practical implications for primary school teachers. Teachers can integrate numeracy into projects that are closely related to students' daily experiences. For example, students can design a simple classroom budget, calculate the cost and profit of a school market project, measure the area and perimeter of the school garden, compare water or electricity consumption, or conduct a class survey and present the results in tables and graphs. Each project should include clear numeracy objectives, structured group roles, worksheets that guide mathematical reasoning, and assessment criteria covering the process and final product. Teachers should also provide regular feedback during the project to help students correct calculation errors, interpret data accurately, and explain their reasoning.

Despite these findings, this study was limited to fifth-grade students at SD 48 and applied a posttest-only control group design. Therefore, the results should be interpreted within the context of the research setting. Future studies should involve larger and more diverse samples, use pretest-posttest designs, and examine the effectiveness of different numeracy projects across grade levels and mathematical topics. Further research may also explore how project duration, group composition, teacher guidance, and students' prior mathematical ability influence the effectiveness of PjBL in developing numeracy skills.

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