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Strengthening mathematical translation through project and problem-based instruction in primary schools

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Abstract

This study investigates the comparative impact of Problem-Based Learning (PBL) and Project-Based Learning (PjBL) on elementary school students' ability to transform word problems into mathematical sentences. The research addresses a critical issue in mathematics education where students often struggle to interpret contextual story problems, which hinders their problem-solving skills. Utilising a quasi-experimental design, the study involved 32 fifth-grade students randomly selected from a population of 56 at SD Negeri Kauman Pleret. Participants were divided equally into control and experimental groups, receiving instruction through the PBL and PjBL models, respectively. Data were collected through written tests and classroom observations, with the validity of assumptions tested via normality and homogeneity checks. An independent samples t-test was used to analyse differences in learning outcomes. The findings reveal that the PjBL model significantly outperformed the PBL model in enhancing students' abilities, with the PjBL group achieving a higher post-test mean score (M = 12.06) compared to the PBL group (M = 9.69). The significance value (p = 0.011) confirms the statistical difference between the two instructional approaches. These results suggest that PjBL is a more effective model for fostering mathematical comprehension through contextual problem-solving tasks, highlighting its potential for broader application in mathematics instruction.

INTRODUCTION

Background of the Study

Education plays a critical role in the holistic development of individuals and societies. In the Indonesian context, the importance of education is embedded within Law No. 20 of 2003 on the National Education System, which emphasizes equitable access to quality education and aims to foster individuals who are faithful, morally upright, democratic, and socially responsible (Aminullah, 2021). Mathematics, as one of the core subjects in the national curriculum, contributes significantly to nurturing logical reasoning, problem-solving, and critical thinkingskills vital for navigating the complexities of modern life (Ariyanti et al., 2023); (Ali & Ahmad., 2023).

Despite the acknowledged importance of mathematics, empirical evidence reveals persistent difficulties among elementary students in comprehending and solving story-based mathematical problems. This is particularly evident in the area of mathematical translation the ability to convert narrative problems into mathematical sentences which forms the foundation for more complex problem-solving processes. Field observations conducted at SD Negeri Kauman Pleret identified two core issues: students' low performance in translating verbal problems into mathematical expressions, especially involving integers, and limited comprehension of comparison concepts. These difficulties often stem from a combination of internal and external factors, such as limited motivation, inadequate instructional resources, and mismatched teaching methods (Rahayu, 2021); (Zulkifli & Nasution., 2021), a pattern also documented internationally among students with word-problem-solving difficulties (Cook, 2020).

In recent years, there has been growing scholarly interest in innovative instructional models that align with the principles of constructivism and real-world application. Among the most prominent are Problem Based Learning (PBL) and Project Based Learning (PjBL). PBL emphasizes student engagement in solving complex, open-ended problems that require critical analysis and teamwork (Cheng & Cheng., 2020); (Anita & Sukirman., 2022), whereas PjBL focuses on student-led projects that integrate knowledge and skills in authentic contexts, thereby enhancing motivation and deep learning (Purwanto et al., 2023). While both models have shown promise in improving cognitive engagement and mathematical understanding, their comparative effectiveness in improving mathematical translation skills remains underexplored, particularly in Indonesian elementary schools.

This study aims to address this research gap by investigating the differential impact of PBL and PjBL on students' abilities to transform mathematical word problems into symbolic expressions. The findings offer not only theoretical contributions to instructional design in mathematics education but also practical insights for teachers seeking to enhance classroom practice through evidence-based pedagogical models.

The Problem of The Study

Despite the central role of mathematics in developing students' critical thinking and problem-solving skills, many elementary school students continue to experience significant challenges in translating verbal story problems into formal mathematical expressions. This skill, known as mathematical translation, is foundational for understanding and solving more complex mathematical problems. Observations at SD Negeri Kauman Pleret revealed that fifth-grade students often struggle with interpreting integer operations and comparative fraction tasks, indicating a deeper difficulty in transforming narrative content into mathematical syntax.

These challenges may be attributed to a range of factors, including insufficient instructional resources, lack of student motivation, and the application of inappropriate teaching strategies. While existing studies highlight the effectiveness of active learning models such as Problem Based Learning (PBL) and Project Based Learning (PjBL) in enhancing mathematical understanding, there remains a lack of empirical comparison between these two models in improving students' ability to convert story problems into mathematical sentences particularly at the elementary level.

The core problem addressed in this study, therefore, is the limited empirical evidence on which instructional model PBL or PjBL is more effective in enhancing students' mathematical translation ability. Bridging this gap is essential for both theoretical advancement in mathematics education and practical improvement in classroom instruction.

Research's State of the Art

The study of mathematical translation, particularly the ability of elementary students to convert narrative word problems into formal mathematical sentences, has garnered increasing scholarly interest in recent years. This skill is recognized as a core component of mathematical literacy, essential for developing higher-order thinking and real-world problem-solving capabilities (Yulianti et al., 2021); (Zhang &

Li., 2022); (Vessonen et al., 2025). However, empirical findings consistently demonstrate that many students face difficulties in this area, often due to a lack of conceptual understanding, language barriers, or ineffective instructional methods (Suherman, 2021); (Wahyuni & Fajri., 2023).

At the theoretical level, the present study is grounded in constructivist learning theory, which posits that students construct knowledge actively through interaction with their environment, particularly through problem-solving and project engagement. Problem Based Learning (PBL) and Project Based Learning (PjBL) are two instructional models rooted in this theoretical tradition. PBL focuses on student engagement through real-world problems that require critical inquiry and collaborative resolution (Zhang & Brown., 2024). Meanwhile, PjBL emphasizes long-term, student-directed projects that apply academic content in meaningful, often interdisciplinary contexts (Utriyani & Susanti., 2022); (Taufiqurrahman & Junaidi., 2021); (Lazić et al., 2021); (Ndiung & Menggo, 2024).

Although both PBL and PjBL have been shown to improve students' engagement, collaboration, and conceptual understanding (Tasya & Abadi., 2020), few studies have systematically compared their specific effects on mathematical translation ability. For example, Noor (2020) found that students often fail to transform story problems into mathematical sentences due to gaps in reasoning and syntax. Simarmata et al. (2020) emphasized the need for appropriate instructional models to strengthen this cognitive bridge. However, most existing research treats PBL and PjBL in isolation without comparing their relative effectiveness in improving translation competence.

Moreover, while the benefits of PBL and PjBL in mathematics education are well-documented in secondary and tertiary contexts, their application in elementary classrooms particularly in developing countries like Indonesia remains underexplored. The originality of this study lies in its comparative design, examining how each model impacts students' ability to translate contextual story problems into mathematical expressions, a skill crucial for foundational mathematical reasoning (Doringin et al., 2023); (Eldin & Hasan., 2021).

This literature-informed gap justifies the current study's focus. By directly comparing the effects of PBL and PjBL on fifth-grade students' mathematical translation abilities, this research not only contributes empirical evidence to the field of mathematics education but also supports teachers and policymakers in

selecting pedagogical strategies that align with students' developmental and contextual needs (Fernandez & Laparra., 2022); (Insani et al., 2023).

Novelty, Research Gap, & Objective

Novelty

This study presents a novel comparative analysis between two prominent student-centered instructional models Problem Based Learning (PBL) and Project Based Learning (PjBL) in their effectiveness to improve mathematical translation ability among elementary school students. While both models are individually recognized for enhancing critical thinking and conceptual understanding, there is a notable lack of research that directly contrasts their specific impact on students' ability to translate narrative word problems into formal mathematical sentences at the primary school level. The study introduces a unique integration of cognitive based evaluation (translation skills) with pedagogical model application in a real classroom context. This novelty offers empirical evidence for improving early mathematical comprehension through comparative pedagogical intervention, particularly within the under-researched Indonesian elementary school system.

Research Gap

Most existing research in mathematics education has examined either PBL or PjBL in isolation, focusing primarily on general achievement, student motivation, or engagement. There is a limited body of literature that explores their comparative impact on a specific sub-skill of mathematical literacy namely, translation from story problems to mathematical expressions. Furthermore, previous studies have disproportionately concentrated on secondary and tertiary education contexts, leaving a significant gap in the literature concerning their implementation and effect in elementary education, especially in developing countries. This research addresses both conceptual and contextual gaps by focusing on an overlooked yet foundational mathematical skill (translation) and applying it in a specific educational stage (fifth-grade students) within a localized Indonesian setting.

Objective

The primary objective of this study is to investigate the differential impact of the Problem Based Learning and Project Based Learning models on the mathematical translation ability of elementary students. Specifically, the study seeks to:

1. Determine students' mathematical translation ability following instruction with the PBL model.
2. Determine students' mathematical translation ability following instruction with the PjBL model.
3. Examine whether there is a statistically significant difference in effectiveness between the PBL and PjBL instructional models in improving students' ability to convert story-based problems into mathematical sentences.

By fulfilling these objectives, the study aims to contribute both theoretically and practically to the field of mathematics education by offering data-driven guidance on effective instructional practices in early-grade mathematical instruction.

METHOD

Type and Design

This study employed a quantitative approach using a quasi-experimental design with a non-equivalent control group. The primary aim was to compare the effectiveness of two instructional models Problem Based Learning (PBL) and Project Based Learning (PjBL) in enhancing the mathematical translation ability of fifth grade students. The quasi-experimental design was chosen due to the practical limitations in fully randomizing the assignment of participants while maintaining ecological validity in a real-school context.

The study involved two groups: an experimental group receiving instruction through the Project Based Learning model and a control group taught using the Problem Based Learning model. Both groups were exposed to equivalent content and learning objectives over a period of four weeks, focusing on translating story-based math problems into formal mathematical expressions. A pre-test and post-test design was used to measure the learning outcomes. The instruments, materials, and treatment modules were developed and validated prior to implementation.

The research was conducted at SD Negeri Kauman Pleret, Bantul Regency, Yogyakarta, Indonesia. The total population included 56 fifth-grade students, from which 32 students were selected through random sampling, ensuring that each student had an equal chance of being included. The sample was then divided equally into two groups (n = 16 for each group). The sample size was determined using the Federer formula for experimental research: $(t - 1)(n - 1) \geq 15$, where t is the number of groups and n is the number of subjects per group. Data collection involved standardized written test instruments designed to assess students'

mathematical translation abilities. The test items were developed based on the curriculum and relevant literature, and they underwent validation for content and construct validity through expert judgment and item analysis. Observation sheets were also used to assess classroom activities during the intervention period.

Normality and homogeneity tests were conducted to ensure the appropriateness of statistical analysis using parametric methods. The final analysis employed an independent samples t-test to compare the post-test scores between the two groups. SPSS software version 26.0 was used for all statistical computations. This study was approved by the Ethics Committee of the Faculty of Teacher Training and Education at Universitas PGRI Yogyakarta. Ethical clearance was obtained under approval code No. 2025/ETIK/MAGISTER-PENDAS/UPY. Parental consent was secured for all participating students, and data confidentiality was maintained throughout the research process. All instructional materials, learning modules, test instruments, and anonymized data used in this study are available upon reasonable request from the corresponding author. No commercial or proprietary restrictions apply to the availability of the materials used.

Data and Data Sources

The data used in this study consisted of both quantitative test results and qualitative classroom observations. The primary data were collected through a pre-test and post-test instrument designed to assess students' ability to translate mathematical story problems into formal mathematical sentences. The tests consisted of structured items that evaluated students' comprehension, analysis, and conversion of contextual narratives into symbolic mathematical expressions. All test items were aligned with the national mathematics curriculum for Grade 5 and validated through expert review and item analysis procedures.

Additional data were collected using observation sheets to monitor student activity and engagement throughout the intervention. These sheets were structured to capture students' interaction, participation, and problem-solving behavior in real-time during the application of PBL and PjBL instructional models.

The data sources in this study were:

1. Primary data: The fifth-grade students of SD Negeri Kauman Pleret, Bantul, Yogyakarta, Indonesia (N = 32), divided into two groups PBL (control) and PjBL (experimental).

2. Secondary data: Curriculum documents, lesson plans, national education standards, and supporting literature from books and peer-reviewed academic journals.

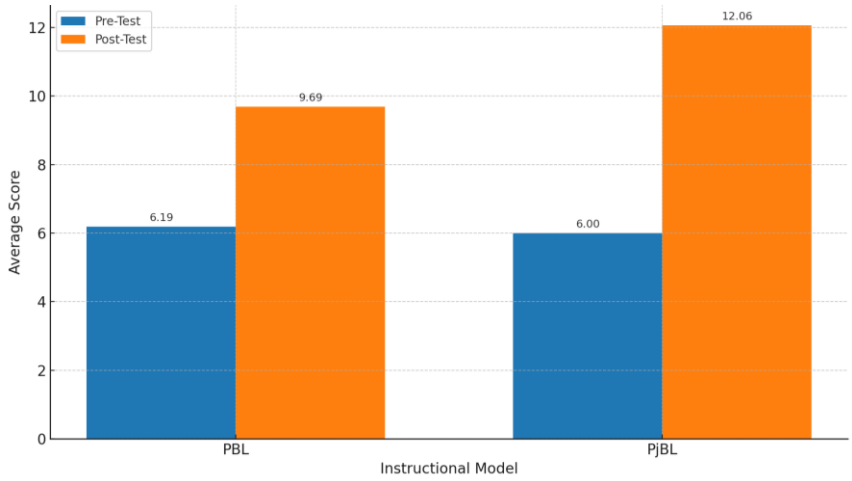
The test scores were collected and analyzed to determine the mean, standard deviation, and gain scores for each group. Table 1 presents the descriptive statistics for both the PBL and PjBL groups before and after the intervention.

Table 1. Pre-Test and Post-Test Scores of Control (PBL) and Experimental (PjBL) Groups

Group	N	Mean Pre-Test	Mean Post-Test	Gain Score
PBL	16	6.19	9.69	3.50
PjBL	16	6.00	12.06	6.06

The statistical difference between the two groups was analyzed using an independent samples t-test. The results showed a significant difference ($p < 0.05$) in the post-test scores, indicating that students in the PjBL group outperformed those in the PBL group. Figure 1 below illustrates the comparison of pre-test and post-test average scores for both groups.

Figure 1. Pre.test and Post-test Comparison Between PBL abd PjBL Groups



The above figure emphasizes the greater improvement experienced by the PjBL group, further supporting the hypothesis that Project Based Learning is more effective in enhancing students' mathematical translation abilities compared to Problem Based Learning. All raw data, instruments, and classroom observation protocols are available from the corresponding author upon reasonable request and may be made available in institutional or public repositories upon publication.

To measure the students' mathematical translation ability, a test instrument was developed consisting of multiple structured story problems that required

students to convert real-life situations into mathematical expressions. The test comprised ten items designed based on the Indonesian elementary mathematics curriculum, particularly focusing on number operations, integer relationships, and problem-solving involving comparison and contextual interpretation.

The development of the instrument followed these stages:

1. Blueprint Construction: The instrument was aligned with learning objectives and cognitive skill levels, including understanding, application, and analysis.
2. Expert Validation: The content validity of the items was evaluated by three mathematics education experts. The Content Validity Index (CVI) was calculated, resulting in a CVI score of 0.92, indicating high content relevance.
3. Item Analysis: A pilot test was conducted with a group of students outside the research sample. Items were analyzed for:
    a. Difficulty Index (P), where acceptable values ranged from 0.30–0.70.
    b. Discrimination Index (D), with acceptable values above 0.30.
    c. Distractor Effectiveness, evaluated based on student response distribution.

Reliability testing using Cronbach's Alpha yielded a coefficient of 0.816, indicating that the instrument had high internal consistency and was suitable for research use. In addition to the written test, observation sheets for both students and teachers were developed to assess engagement and adherence to the PBL and PjBL learning protocols. These instruments were also validated through expert review for clarity, relevance, and construct alignment.

Data analysis was conducted using descriptive and inferential statistics. The descriptive statistics included the computation of means, standard deviations, and gain scores to compare the performance of students before and after the treatment in both groups. To test the research hypothesis, inferential analysis was conducted using the independent samples t-test. This test was selected to determine whether there were statistically significant differences in post-test scores between the control (PBL) and experimental (PjBL) groups. Prior to performing the t-test, the following assumption tests were applied:

1. Normality Test using the Shapiro-Wilk method for small samples ($n < 50$).
2. Homogeneity of Variance Test using Levene's Test to ensure equal variance between groups.

Both assumptions were met, confirming the appropriateness of the parametric test. The significance level (α) was set at 0.05. Data analysis was performed using SPSS Version 26.0. A p-value less than 0.05 was interpreted as statistically

significant. Furthermore, qualitative data from classroom observations were used to support and interpret the quantitative results, offering insights into the dynamics of student engagement, instructional effectiveness, and challenges encountered during implementation.

Data Collection Technique

The data in this study were collected through two primary techniques: written tests and structured classroom observations.

1. Written Tests: A pre-test and post-test were administered to both the control group (PBL) and the experimental group (PjBL). These tests were designed to assess students' ability to translate mathematical story problems into formal mathematical sentences. The pre-test was conducted prior to the instructional intervention, and the post-test was administered after the completion of the four-week treatment period.
2. Classroom Observations: Observational data were gathered using validated observation sheets for both teachers and students. These instruments were used to monitor learning activities, student engagement, and the implementation fidelity of the instructional models during the learning process.

All data collection activities were conducted during regular classroom hours with the consent of the school, teachers, and parents, ensuring ethical compliance and minimal disruption to the learning environment.

Data Analysis

Data analysis in this study was conducted systematically to determine the effectiveness of the Problem Based Learning (PBL) and Project Based Learning (PjBL) models in improving students' mathematical translation abilities. The analysis involved multiple stages including data cleaning, data transformation, assumption testing, and statistical hypothesis testing, all conducted with the assistance of SPSS version 26.0.

1. Data Cleaning and Preparation

   Before analysis, all raw data from the pre-test and post-test results were reviewed for completeness and consistency. Student answer sheets were checked to ensure no missing responses or ambiguous entries. Any incomplete data entries were excluded from analysis. The scores were then entered into SPSS and cross-verified to eliminate data entry errors.
2. Scoring and Gain Calculation

Each student's pre-test and post-test responses were scored based on a pre-determined rubric validated by subject-matter experts. Each item had a maximum score of one point, with total scores ranging from 0 to 10. After scoring, a gain score was calculated for each student by subtracting the pre-test score from the post-test score. This score was used to measure learning improvement resulting from the intervention.

3. Descriptive Statistics

   Descriptive statistical analysis was carried out to summarize the central tendencies and dispersion of the data, including:

   a. Mean (average score)
   b. Standard deviation (variability of scores)
   c. Minimum and maximum scores
   d. Gain score distribution

   This analysis helped provide an initial overview of student performance before and after the treatment in each group.

4. Assumption Testing

   Prior to conducting inferential analysis, two key statistical assumptions were tested to determine the suitability of parametric methods:

   a. Normality Test with The Shapiro-Wilk test was employed due to the small sample size ($n < 50$). The normality test was performed separately for the pre-test and post-test scores in both the PBL and PjBL groups. A significance value ($p > 0.05$) indicated that the data were normally distributed.
   b. Homogeneity of Variance Test with Levene's Test for equality of variances was used to assess whether the variances of the two groups were statistically equal. A p-value greater than 0.05 indicated homogeneity, satisfying the condition for applying the independent samples t-test. Both assumptions were met, confirming that the use of parametric testing was appropriate for the data.

5. Inferential Statistics

   The primary statistical test employed was the independent samples t-test to compare the post-test mean scores of the control group (PBL) and the experimental group (PjBL). The objective was to determine whether there was a statistically significant difference in the students' mathematical translation abilities after treatment. The t-test was conducted under the following hypothesis framework:

a. Null Hypothesis (H_0) is there is no significant difference in the mathematical translation ability between students taught using the PBL model and those taught using the PjBL model.
b. Alternative Hypothesis (H_1) is there is a significant difference in the mathematical translation ability between students taught using the PBL model and those taught using the PjBL model.

The decision to accept or reject the null hypothesis was based on the p-value ($\alpha = 0.05$). A p-value less than 0.05 was considered statistically significant, indicating a difference between the two groups.

6. Effect Size Measurement

To complement the t-test result, the effect size was calculated using Cohen's d, which quantifies the magnitude of the difference between the two groups. The interpretation followed standard conventions:

a. 0.2 = small effect
b. 0.5 = moderate effect
c. 0.8 or above = large effect

This measure helped assess the practical significance of the findings beyond mere statistical significance.

7. Triangulation with Observational Data

In addition to quantitative test scores, qualitative data from classroom observation were analyzed descriptively to support the interpretation of test results. Observations included student participation, collaboration, use of mathematical language, and engagement during the learning process. These qualitative insights helped explain behavioral patterns and contextual factors influencing the outcome.

8. Conclusion Drawing and Interpretation

Based on the results of the descriptive and inferential analyses, final conclusions were drawn regarding the effectiveness of each instructional model. These conclusions were then interpreted in light of existing literature and theoretical frameworks, particularly constructivist learning theory and its emphasis on active, contextual learning.

RESULTS

This section reports the outcomes of a quasi-experimental study that aimed to compare the effectiveness of Problem Based Learning (PBL) and Project Based

Learning (PjBL) models on students' ability to translate mathematical story problems into mathematical sentences. The analysis is divided into three major subsections: descriptive statistics, inferential statistics, and qualitative observation outcomes. Each subsection is presented in detail with accompanying tables.

1. Descriptive Statistical Analysis

   Descriptive statistics were computed to assess students' pre-test and post-test performance within the PBL and PjBL groups.

Table 2. Pre-Test and Post-Test Results for the PBL Group

No	Pre-Test	Post-Test
1	11	11
2	14	15
3	4	7
4	13	11
5	11	12
6	5	7
7	10	10
8	7	8
9	4	9
10	9	10
11	12	12
12	5	8
13	6	8
14	10	10
15	5	9
16	8	8
Mean	**8.375**	**9.6875**

   This data indicates an improvement of 1.3125 points in the average score after implementing PBL.

2. Experimental Group (PjBL)

Table 3. Pre-Test and Post-Test Results for the PjBL Group

No	Pre-Test	Post-Test
1	10	15

2	5	11
3	12	15
4	6	12
5	4	6
6	11	13
7	5	9
8	6	10
9	12	15
10	7	12
11	6	9
12	12	15
13	8	10
14	10	14
15	8	12
16	14	15
Mean	**8.5**	**12.0625**

This table demonstrates a 3.5625-point increase, indicating that PjBL had a more pronounced effect on improving mathematical translation abilities.

3. Inferential Statistical Analysis

To assess the statistical significance of the observed differences, an independent samples t-test was conducted after validating assumptions of normality and homogeneity.

a. Assumption Testing

This is result The Normality Test (Shapiro-Wilk)

PBL Group: p = 0.277

PjBL Group: p = 0.122

Both p-values > 0.05, indicating data are normally distributed.

b. Homogeneity of Variances (Levene's Test):

Table 4. Homogeneity of Variance (Pre-Test)

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.281	1	0.281	0.041	0.841
Within	206.938	30	6.898		

Groups		
Total	**207.219**	31

Sig = 0.841 > 0.05, indicating equal variances.

c. Independent Samples t-Test

Table 5. t-Test Results Comparing PBL and PjBL Groups (Post-Test)

Variance Assumption	**t**	**df**	**Sig. (2-tailed)**	**Mean Diff**	**Std. Error**	**95% CI (Lower–Upper)**
Equal variances assumed	2.724	30	**0.011**	2.375	0.872	0.595 – 4.155
Equal variances not assumed	2.724	28.385	**0.011**	2.375	0.872	0.590 – 4.160

The p-value of 0.011 confirms a statistically significant difference in post-test performance favoring the PjBL group.

4. Observation Results

To complement the quantitative findings, observation sheets were analyzed, documenting students' behavioral and cognitive engagement during classroom implementation.

a. PBL Group Observations:

1) Students demonstrated modest enthusiasm at the beginning but were often confused by abstract problem formulations.
2) Some students needed teacher intervention to sustain engagement.
3) Collaboration occurred but lacked consistent depth.
4) Limited verbal articulation of reasoning was observed.

b. PjBL Group Observations:

1) Students actively engaged in group projects, such as converting daily narratives into math problems.
2) Discussions were vibrant, and students frequently verbalized mathematical reasoning.
3) Higher levels of collaboration and creativity were evident.
4) Students independently initiated problem formulations using real-world themes.

These observations supported the quantitative result that PjBL facilitated not only better test outcomes but also richer learning experiences.

5. Experimental Conclusions

Based on the quantitative and qualitative findings, the following conclusions were drawn:

a. Both PBL and PjBL improved students' mathematical translation skills.
b. The PjBL group showed a greater improvement (gain = 3.5625) than the PBL group (gain = 1.3125).
c. A statistically significant difference (p = 0.011) was found between the two groups' post-test scores.
d. Observational data indicated that PjBL promoted higher student motivation, collaboration, and contextual understanding.

Thus, Project Based Learning is demonstrably more effective than Problem Based Learning in enhancing elementary students' abilities to transform narrative problems into mathematical sentences.

DISCUSSIONS

The findings of this study provide compelling evidence that the Project Based Learning (PjBL) model is more effective than the Problem Based Learning (PBL) model in enhancing elementary students' ability to translate mathematical story problems into mathematical sentences. This section interprets the results in light of existing theories, prior empirical studies, the study's hypotheses, and broader educational implications.

1. Interpretation of Findings in Light of Prior Research

The statistically significant improvement in the PjBL group, as indicated by a gain score of 3.5625 compared to 1.3125 in the PBL group (p = 0.011), supports the central hypothesis of this research: that PjBL facilitates deeper understanding and better mathematical application in contextual problems. These findings are consistent with the constructivist learning theory that underpins both models but are especially aligned with the principles of authentic learning in PjBL.

Several previous studies reinforce this conclusion. Taufiqurrahman and Junaidi (2021) found that PjBL enables students to integrate abstract concepts with real-world application through hands-on projects. Similarly, Iryanto (2021) reported that students engaged in PjBL contexts demonstrated higher levels of

engagement and retention in mathematics learning. These findings echo evidence from other national contexts: Lazić et al. (2021), working in South Africa, similarly found that project-based learning raised elementary students' mathematics achievement, while Rehman et al. (2023) reported that math-based project learning fostered stronger problem-solving and collaboration skills among primary school students in an international sample, and Kim and Kim (2021) observed that small-group project-based activities in mathematics classrooms strengthened students' motivation and mathematical communication. In parallel, Vessonen et al. (2025), in a large-scale international meta-analysis, confirmed that structured, well-implemented interventions produce strong gains in elementary students' mathematical word-problem-solving skills, reinforcing the relevance of instructional design choices such as PjBL for the mathematical translation skill examined in this study. The present study contributes to this body of research by applying these insights to a specific cognitive skill mathematical translation which has often been overlooked in comparative instructional studies.

In contrast, while PBL promotes critical thinking through problem exploration, students in the control group showed more hesitation and reliance on teacher prompts. This aligns with Anita & Sukirman (2022), who found that students with limited prior knowledge may struggle with the open-ended nature of PBL tasks unless scaffolded properly. Therefore, while PBL remains effective for promoting inquiry, its impact on precise skills such as mathematical syntax construction may be less direct than PjBL, which emphasizes the step-by-step formulation of problems.

2. Cognitive and Pedagogical Implications

   The greater improvement observed in the PjBL group can be attributed to several pedagogical factors:

   a. Authenticity and Relevance: Students were given tasks that connected mathematics to their daily experiences—e.g., planning purchases, analyzing measurements, and solving real-life scenarios. This increased motivation and helped solidify the link between language and symbolization.
   b. Collaborative Learning: PjBL emphasized teamwork and student-led inquiry, which fostered peer teaching, more frequent discussion, and greater retention of concepts.

c. Project Artifacts: The requirement to create tangible outputs (e.g., charts, diagrams, and written explanations) deepened student engagement and understanding.

In contrast, PBL, though structured around rich problem-solving experiences, appeared to require more cognitive scaffolding. Students in the PBL group often faced difficulties interpreting the given scenarios into symbolic language, especially when lacking prior conceptual readiness. This suggests that while PBL is powerful in developing reasoning, PjBL may offer clearer pathways for building procedural and representational skills in mathematical contexts.

3. Implications for Curriculum and Instruction

The implications of this study for curriculum designers and classroom practitioners are significant:

a. Elementary school curricula should incorporate more project-based modules, especially in mathematics instruction, to cultivate translation and application skills.
b. Teacher training should include modules on developing and assessing mathematical translation through contextual project designs.
c. Schools should consider integrating interdisciplinary projects, connecting mathematics with language and social studies to mirror real-life problem contexts.

Furthermore, assessment systems may benefit from including tasks that measure not just procedural fluency, but the ability to translate, interpret, and represent real-world problems mathematically.

4. Limitations and Future Research Directions

While the findings are robust, this study was limited to a single school with a relatively small sample size (N = 32). The cultural and contextual uniqueness of SD Negeri Kauman Pleret may limit the generalizability of the findings to other settings. Additionally, the intervention was conducted over a short period (four weeks), which may not capture the long-term impact of the instructional models. Future research is recommended in the following directions:

a. Conduct longitudinal studies to examine the sustained impact of PjBL and PBL on mathematical thinking and academic outcomes.
b. Explore the integration of digital tools in PjBL to support hybrid and technology-enhanced learning environments.

c. Replicate the study with larger and more diverse populations to strengthen external validity and explore variations across grade levels, regions, and school types.
d. Investigate the interaction of learning styles and instructional models to personalize math instruction based on students' cognitive and social preferences.

This study provides strong empirical support for the effectiveness of Project Based Learning in fostering mathematical translation ability among elementary students. By engaging students in contextual, collaborative, and purposeful learning experiences, PjBL not only enhances academic performance but also promotes deeper understanding and lifelong learning habits. The implications of this research extend beyond instructional preferences they touch on broader questions of how to make mathematics more accessible, meaningful, and relevant for all learners.

CONCLUSION

This study concludes that the Project Based Learning (PjBL) model is significantly more effective than the Problem Based Learning (PBL) model in improving fifth-grade students' ability to translate mathematical story problems into formal mathematical sentences, thereby answering the research problem posed in this study. This conclusion is supported by the higher post-test mean score obtained by the PjBL group (M = 12.06) compared to the PBL group (M = 9.69), with an independent samples t-test confirming a statistically significant difference between the two groups ($p = 0.011 < 0.05$).

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