IJORER: International Journal of Recent Educational Research
Homepage: https://journal.ia-education.com/index.php/ijorer
Emal: ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

# Integrated Project-Based Learning and Inquiry in Fraction Instruction: A Quasi-Experimental Study of Fifth-Grade Mathematics Achievement in Ende, Indonesia

**Marselina Wali[1*], Agnes Remi Rando[2]**
[1,2]Universitas Flores, Nusa Tenggara Timur, Indonesia

Check for updates OPEN ACCESS

**DOI :** https://doi.org/10.46245/ijorer.v7i6.1618

**Sections Info**

***Article history:***
Submitted: September 04, 2026
Final Revised: Nov. 09, 2026
Accepted: November 30, 2026
Published: November 30, 2026

***Keywords:***
Project-Based Learning; Inquiry; Mathematics Achievement; Elementary Education; Quasi-Experiment

**ABSTRACT**

**Objective**: This study examined the effectiveness of an integrated project-based learning and inquiry model in improving mathematics achievement among fifth-grade students in Ende, Indonesia, where mathematics instruction remains predominantly teacher-centered and procedurally focused despite curricular mandates that promote student-centered approaches. **Method**: A quasi-experimental pretest-posttest control group design was employed with 76 fifth-grade students from two public elementary schools, 38 in the experimental group and 38 in the control group. The experimental group received the integrated PBL-inquiry model and the control group received conventional instruction on the topic of fractions over eight weeks. Achievement was measured with a 20-item multiple-choice test and analyzed using an independent samples t-test on gain scores and a one-way ANCOVA with pretest scores as the covariate. **Results**: The experimental group achieved a higher mean gain ($M = 28.42$, $SD = 8.76$) than the control group ($M = 19.63$, $SD = 7.41$), $t(74) = 4.73$, $p < 0.001$, Cohen's $d = 1.08$. ANCOVA confirmed the effect after adjustment for pretest performance, $F(1, 73) = 22.18$, $p < 0.001$, partial eta squared = 0.233. **Novelty**: The study provides empirical evidence on the integration of project-based learning and inquiry within a single instructional framework for elementary mathematics, an arrangement that remains underexplored in Indonesian primary education research, and it reports the magnitude of the effect alongside the implementation conditions that produced it.

## INTRODUCTION

Mathematics is a fundamental subject in elementary education that serves as a basis for advanced academic study and as a critical tool for everyday reasoning and problem solving (Lazić et al., 2021). In many countries, including Indonesia, mathematics remains one of the most challenging subjects for elementary school students (Yurniwati & Hanum, 2016). International large-scale assessments such as the Programme for International Student Assessment (PISA) consistently reveal that Indonesian students perform substantially below the global average in mathematics, particularly in domains that require higher-order thinking and application of concepts to unfamiliar situations (OECD, 2023). The most recent cycle confirmed that the decline recorded since 2015 has not been reversed, that performance in mathematics fell again between 2018 and 2022, and that the proportion of students who do not reach the baseline level of proficiency has grown relative to a decade earlier (OECD, 2023). The conventional approach to mathematics teaching, which typically follows a direct instruction model where the teacher explains concepts, demonstrates procedures, and assigns practice problems, has been the predominant method in Indonesian classrooms for decades (Lazić et al., 2021). While this approach can convey procedural knowledge efficiently, it often falls short in developing students' conceptual understanding, problem-solving skills, and intrinsic motivation toward mathematics (AY Emanet & Kezer, 2021).

IJORER: International Journal of Recent Educational Research
Homepage: https://journal.ia-education.com/index.php/ijorer
Emal: ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

The limitations of conventional mathematics instruction have prompted educators and researchers around the world to explore student-centered approaches that place learners at the center of the educational process (Turgut & Turgut, 2018). A meta-analysis of student-centered teaching methods in mathematics found that problem-based learning, cooperative learning, and inquiry-based learning produced significantly higher achievement than traditional teacher-centered methods, with moderate to large effect sizes across grade levels and mathematical topics (AY Emanet & Kezer, 2021). Inquiry-based approaches to mathematics learning have been shown not only to improve achievement but also to foster deeper conceptual understanding and more positive attitudes toward the subject (Beswick, 2021). Evidence from mathematics classrooms organized around projects points in the same direction and adds outcomes that achievement tests do not capture, namely higher student engagement together with stronger collaboration and problem-solving capacity (Rehman et al., 2024). These findings have contributed to a growing recognition that mathematics education must evolve beyond rote memorization and procedural repetition to embrace approaches that engage students actively in constructing their own mathematical knowledge (Lerman, 1989; Setiana et al., 2020).

Among the various student-centered instructional models, project-based learning (PBL) has emerged as one of the most promising approaches for elementary education (Hmelo-Silver, 2004). PBL is an instructional method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge, during which they design, plan, and produce a tangible product or presentation that demonstrates their learning (Hmelo-Silver, 2004). Effective PBL environments provide learners with opportunities to construct knowledge through collaborative problem solving, self-directed learning, and reflective thinking (Hmelo-Silver, 2004). In the context of mathematics education, PBL allows students to explore mathematical concepts through real-world applications, connecting abstract formulas and procedures to meaningful contexts that make learning more relevant and motivating (Lazić et al., 2021). A quasi-experimental study conducted in elementary schools found that students who learned mathematics through PBL achieved significantly higher scores than those who received conventional instruction, with particularly strong effects on problem solving and conceptual understanding (Lazić et al., 2021). In the Indonesian context, PBL has been shown to improve elementary school mathematics learning outcomes (Siswadi et al., 2024), while problem-based learning has been found to increase student engagement in elementary mathematics learning (Anugraheni et al., 2025). Systematic reviews of this literature describe a field that is expanding quickly but unevenly, implemented through heterogeneous designs and reported with inconsistent attention to the classroom conditions under which the approach actually works (Nguyen et al., 2024).

Alongside PBL, inquiry-based learning represents another important student-centered approach that has gained considerable attention in mathematics education research (Beswick, 2021). Inquiry-based learning is an approach that emphasizes the process of discovery through questioning, investigation, and reflection, guiding students through a structured cycle of asking questions, conducting investigations, gathering evidence, and drawing conclusions (Margunayasa et al., 2021). At the elementary level, guided inquiry is often the most appropriate form, as it provides sufficient structure to support young learners while still encouraging active investigation and critical thinking

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

(Margunayasa et al., 2021). Guided inquiry learning has been demonstrated to reduce misconceptions among elementary school students and to improve their conceptual understanding (Margunayasa et al., 2021). Similarly, guided discovery learning, an approach closely related to inquiry, has produced significant improvements in the mathematics achievement of fifth-grade students in Indonesia (Yurniwati & Hanum, 2016). When inquiry cycles are paired with structured peer collaboration, the benefit extends to the higher-order skills that routine exercises rarely reach, and a quasi-experimental study of fourth-grade students reported significant gains in analytical thinking and mathematical reasoning relative to conventional teaching (Yu et al., 2024). Problem-based approaches in elementary mathematics, when combined with literacy-oriented tasks, have also been shown to enhance both mathematical performance and reading comprehension, suggesting that interdisciplinary applications of student-centered models can yield multiple academic benefits (Farhan et al., 2021).

Despite the well-documented benefits of both PBL and inquiry-based learning as separate instructional strategies, relatively little research has examined how these two approaches can be integrated within a single instructional framework (Lethulur et al., 2025). A systematic literature review of discovery, inquiry, problem-based, and project-based learning in mathematics education noted that while all four approaches have demonstrated positive effects on student outcomes, studies that combine or integrate these approaches remain scarce (Lethulur et al., 2025). A more recent review of problem-based learning in school mathematics arrives at a related observation, reporting that integrated implementations were more frequent among the studies it identified than exclusive implementations of a single model, which suggests that practitioners already combine models in practice while the research literature continues to test them one at a time (Ayari et al., 2025). This represents a significant gap because, in practice, the boundaries between PBL and inquiry are often fluid. Authentic projects frequently require students to engage in systematic inquiry processes such as formulating questions, designing investigations, and analyzing evidence, while inquiry activities can be embedded within larger project structures that culminate in tangible products (Beswick, 2021; Hmelo-Silver, 2004). Integrating PBL and inquiry into a cohesive model may capitalize on the strengths of both approaches to create a more powerful learning experience than either approach could offer alone (Lethulur et al., 2025).

The theoretical rationale for integrating PBL and inquiry is grounded in constructivist learning theory, which posits that learners actively construct knowledge through experiences, reflection, and interaction with their environment (Lerman, 1989). In a PBL-inquiry integrated model, students engage with a driving question or authentic problem that provides the overarching project context, then proceed through structured inquiry cycles to investigate sub-questions, gather and analyze data, and develop solutions that are synthesized into a final project product (Beswick, 2021; Hmelo-Silver, 2004). This integrated approach aligns with the principles of effective mathematics instruction that emphasize the importance of providing students with authentic tasks, encouraging active investigation, and fostering collaborative discourse (Beswick, 2021). It also addresses the motivational dimensions of mathematics learning. Perceived teacher support and engaging instructional approaches have been found to predict students' mathematics interest (Oppermann & Lazarides, 2021), and mathematics classrooms organized around projects have been reported to sustain engagement through the visibility of the work students produce and defend (Rehman et al., 2024).

IJORER: International Journal of Recent Educational Research
Homepage: https://journal.ia-education.com/index.php/ijorer
Emal: ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

The present study aims to address the gap in the literature by examining the effectiveness of an integrated project-based learning and inquiry model on mathematics achievement among elementary school students in Indonesia. Three research questions organize the inquiry. First, is there a significant difference in mathematics achievement gain between students taught with the integrated PBL-inquiry model and students taught through conventional instruction? Second, does that difference remain significant once pretest achievement is controlled statistically? Third, how large is the effect of the integrated model on mathematics achievement? The third question is not incidental. An instructional model is worth the demands it places on a teacher only when the size of its effect is known, and statistical significance alone does not answer that question. The study therefore reports both the significance of the difference and the magnitude of the effect, and it examines the conditions of implementation under which that magnitude was obtained.

## RESEARCH METHOD

### Research Design

This study employed a quasi-experimental pretest-posttest control group design to examine the effectiveness of an integrated project-based learning and inquiry model on elementary school students' mathematics achievement (Creswell, 2002; Creswell & Creswell, 2018). The design was chosen because random assignment of individual students is not feasible when instruction is delivered to intact classes and the school timetable cannot be rearranged for research purposes. The independent variable was the instructional model, with two levels: the integrated PBL-inquiry model for the experimental group and conventional instruction for the control group. The dependent variable was students' mathematics achievement as measured by pretest and posttest scores. The pretest was administered before the treatment to establish baseline equivalence between the two groups, and the posttest was administered after the eight-week treatment period to measure the effect of the instructional model. Because the groups were formed from intact classes rather than by individual randomization, the analysis was designed to reduce the influence of pre-existing differences instead of assuming that none existed, and two strategies served that purpose, namely a comparison of gain scores and an analysis of covariance that adjusts posttest means for pretest performance.

### Participants

The population consisted of fifth-grade students enrolled in public elementary schools in Ende, Indonesia. Fifth-grade students were selected because the mathematical topic covered in this study, fractions, is a core component of the fifth-grade curriculum in Indonesia and represents an area in which many students experience difficulty (Yurniwati & Hanum, 2016). Schools were screened against three criteria before being invited to participate: comparability of the demographic profile of the school catchment area, comparability of average fifth-grade class size, and the willingness of the school leadership and the mathematics teacher to sustain participation across the full eight weeks of treatment. Those criteria were selected because differences in intake and in class size are the most plausible school-level alternatives to an instructional explanation for any difference observed at the end of the treatment, and because a school that withdraws midway leaves both groups incomparable. Two public elementary schools met all three

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

criteria and were selected purposively. One school was then assigned at random to the experimental condition and the other to the control condition. A total of 76 students participated, with 38 students in the experimental group and 38 in the control group. The experimental group consisted of 20 male and 18 female students with a mean age of 11.2 years (SD = 0.41), while the control group consisted of 21 male and 17 female students with a mean age of 11.1 years (SD = 0.38).

Baseline equivalence was examined on three indicators rather than one. An independent samples t-test on pretest scores indicated no significant difference between the groups, $t(74) = 0.67$, $p = 0.505$. Levene's test indicated that the variance of pretest scores did not differ significantly across the groups, so a pooled-variance procedure was appropriate. The composition of the two groups was also similar in sex and in age. These indicators support the reading that both groups began the study at comparable levels of achievement in the topic under study. What they cannot establish is equivalence on characteristics that were not measured, such as earlier exposure to student-centered instruction or differences in teacher experience, and the analysis therefore reports an unadjusted comparison of gains alongside an adjusted comparison that partials out pretest performance, so that the conclusion does not rest on the assumption of perfect equivalence.

**Instruments**

Mathematics achievement was measured using a researcher-developed test comprising 20 multiple-choice items aligned with the fifth-grade fractions curriculum in Indonesia. The blueprint combined a content dimension with a cognitive dimension. The content dimension followed the four fraction topics taught during the treatment, namely the concept of fractions, comparison and ordering, conversion between improper fractions and mixed numbers, and addition, subtraction, multiplication, and division of fractions. The cognitive dimension followed three levels. Four items assessed factual knowledge of definitions and notation, ten items assessed procedural application, and six items assessed conceptual understanding and problem solving. The resulting distribution placed half of the test at the procedural level and slightly less than one third at the conceptual level, which reflects the weight that the curriculum gives to fluent computation while still requiring students to interpret situations rather than only to apply rules. Each item was scored one point for a correct response and zero otherwise, and the total was converted to a scale of 0 to 100 so that a score could be read as a percentage of the maximum. Content validity was established by two experts in elementary mathematics education who reviewed the items for curriculum alignment, clarity, and difficulty. The test was pilot-tested with 30 fifth-grade students from a third school not included in the main study. The pilot test yielded a Cronbach's alpha of 0.83, indicating good internal consistency. Item analysis revealed that all 20 items had discrimination indices above 0.30 and difficulty indices between 0.30 and 0.80, which indicates that the items separated stronger from weaker students without being either trivial or inaccessible (AY Emanet & Kezer, 2021).

**Treatment Procedures**

The treatment was implemented over a period of eight consecutive weeks during the regular mathematics instructional time. Both groups received five 35-minute mathematics sessions per week, totaling 40 sessions over the eight-week period, and both groups were taught the same fractions content as specified in the fifth-grade curriculum:

IJORER: International Journal of Recent Educational Research
Homepage: https://journal.ia-education.com/index.php/ijorer
Emal: ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

understanding fraction concepts, comparing and ordering fractions, converting between improper fractions and mixed numbers, and performing addition, subtraction, multiplication, and division of fractions.

The experimental group received instruction using the integrated PBL-inquiry model. In this model, each two-week unit began with the presentation of an authentic driving question or real-world problem related to fractions. For example, in the unit on fraction operations, students were presented with the challenge of planning a class party within a given budget, requiring them to calculate fractional amounts of ingredients, costs, and materials. Following the driving question, students engaged in structured inquiry cycles that involved formulating sub-questions, designing investigations, collecting and analyzing data, and drawing conclusions (Beswick, 2021; Hmelo-Silver, 2004). The teacher facilitated the learning process by posing probing questions, providing guidance when needed, and encouraging collaborative discussion, consistent with the guided inquiry approach recommended for elementary students (Margunayasa et al., 2021). At the end of each two-week unit, students presented their project products, which included posters, models, or written reports demonstrating their mathematical reasoning and solutions.

The control group received conventional mathematics instruction based on the direct instruction model commonly used in Indonesian elementary schools (Siswadi et al., 2024). Each session began with the teacher explaining the mathematical concept or procedure, followed by worked examples on the board, guided practice through teacher-led exercises, and independent practice through textbook problems. The teacher controlled the pace of instruction, and students primarily worked individually.

### Data Analysis

Data were analyzed using IBM SPSS Statistics version 26. Before hypothesis testing, the data were screened for missing values, outliers, and violations of statistical assumptions. No missing data or significant outliers were identified. The normality of pretest and posttest scores was assessed using the Kolmogorov-Smirnov test, and homogeneity of variances was tested using Levene's test. Both assumptions were satisfied ($p > 0.05$). Descriptive statistics were computed for both groups. To test the hypothesis that the integrated PBL-inquiry model produced significantly higher mathematics achievement than conventional instruction, an independent samples t-test was conducted on the gain scores, calculated as the difference between posttest and pretest scores for each student. In addition, a one-way analysis of covariance (ANCOVA) was performed with posttest scores as the dependent variable, instructional model as the independent variable, and pretest scores as the covariate. The ANCOVA provides a more sensitive test of group differences by statistically controlling for any pre-existing differences between the groups (Creswell & Creswell, 2018). Effect sizes were calculated using Cohen's d for the t-test and partial eta squared for the ANCOVA. The significance level was set at alpha = 0.05.

## RESULTS AND DISCUSSION

### *Results*

### Pretest Analysis

Before examining the effect of the integrated PBL-inquiry model, the pretest scores of the two groups were compared to establish baseline equivalence. The experimental group

IJORER: International Journal of Recent Educational Research
Homepage: https://journal.ia-education.com/index.php/ijorer
Emal: ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

obtained a mean pretest score of 42.37 (SD = 8.14), while the control group obtained a mean of 43.68 (SD = 8.51), a difference of 1.31 points in favor of the control group. An independent samples t-test revealed that this difference was not statistically significant, $t(74) = 0.67$, $p = 0.505$, and the two groups were therefore treated as comparable in their baseline mathematics achievement. The direction of the small initial difference is worth noting, because it works against the hypothesis of the study rather than for it: the group that later received conventional instruction began slightly ahead of the group that received the integrated model.

**Descriptive Statistics and Gain Scores**

Table 1 reports the means and standard deviations of the pretest, posttest, and gain scores for both groups. Three features of the table organize the analysis that follows. First, both groups improved. The experimental group moved from a mean of 42.37 to 70.79, an increase of 28.42 points, and the control group moved from 43.68 to 63.32, an increase of 19.63 points, so that conventional instruction was not ineffective but produced less than three quarters of the gain obtained under the integrated model. Second, the dispersion of scores narrowed in both groups, from standard deviations close to eight on the pretest to approximately seven on the posttest, and the narrowing was comparable in the two groups. Third, the difference between the conditions appears in the individual gain and not only in the group mean. The mean gain of the experimental group exceeded that of the control group by 8.79 points, while the standard deviations of the gain scores, 8.76 and 7.41 respectively, indicate that the two distributions overlap only partially.

**Table 1.** Pretest, Posttest, and Gain Scores by Group

| Group | N | Pretest M (SD) | Posttest M (SD) | Gain M (SD) |
|---|---|---|---|---|
| Experimental | 38 | 42.37 (8.14) | 70.79 (6.83) | 28.42 (8.76) |
| Control | 38 | 43.68 (8.51) | 63.32 (6.95) | 19.63 (7.41) |

**Hypothesis Testing: Independent Samples t-test**

An independent samples t-test was conducted on the gain scores to determine whether the integrated PBL-inquiry model produced significantly higher mathematics achievement than conventional instruction. Table 2 presents the result. The experimental group achieved a significantly higher mean gain score than the control group, $t(74) = 4.73$, $p < 0.001$. The effect size, measured by Cohen's d, was 1.08. Placing that value against the dispersion of the two groups, which combines to a pooled standard deviation of approximately 8.11 points, shows that the mean gain of the experimental group lay about one standard deviation above the mean gain of the control group. The test statistic and the standardized difference therefore agree, and the standardized difference is the more informative of the two, because it does not depend on the length of the scale on which the test happened to be scored.

**Table 2.** Independent Samples t-test on Gain Scores

| Group | M | SD | df | t | p | Cohen's d |
|---|---|---|---|---|---|---|
| Experimental | 28.42 | 8.76 | 74 | 4.73 | < .001 | 1.08 |
| Control | 19.63 | 7.41 | | | | |

**Hypothesis Testing: ANCOVA**

A one-way ANCOVA was conducted with posttest scores as the dependent variable, instructional model as the independent variable, and pretest scores as the covariate. The

IJORER: International Journal of Recent Educational Research
Homepage: https://journal.ia-education.com/index.php/ijorer
Emal: ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

covariate was related to the outcome, F(1, 73) = 12.67, p = 0.001, partial eta squared = 0.148, which confirms that baseline achievement carried information about later achievement and that the adjustment was warranted. After that adjustment the instructional model remained significant, F(1, 73) = 22.18, p < 0.001, partial eta squared = 0.233, and the model accounted for 23.3% of the variance in posttest scores that remained after the covariate had taken its share. Table 3 reports the full partition of the variation, with 669.02 attributable to the instructional model, 382.14 to the covariate, and 2201.86 of residual variation distributed across 73 degrees of freedom, which leaves a mean square of 30.16 against which both effects were tested.

**Table 3.** ANCOVA Results

| Source | SS | df | MS | F | p | Partial eta squared |
|---|---|---|---|---|---|---|
| Pretest (Covariate) | 382.14 | 1 | 382.14 | 12.67 | .001 | .148 |
| Instructional Model | 669.02 | 1 | 669.02 | 22.18 | < .001 | .233 |
| Error | 2201.86 | 73 | 30.16 | | | |

The adjusted posttest means, controlling for pretest scores, were 71.12 for the experimental group and 62.97 for the control group, a difference of 8.15 points in favor of the experimental group. The adjustment moved the unadjusted posttest difference of 7.47 points only modestly, which is what one expects when the groups begin at comparable levels, and the three estimates available in this analysis, namely 7.47 unadjusted, 8.15 adjusted, and 8.79 from the gain scores, converge on the same conclusion rather than pointing in different directions.

### *Discussion*

The findings provide strong empirical evidence that the integrated project-based learning and inquiry model is more effective than conventional instruction in improving elementary school students' mathematics achievement. The experimental group outperformed the control group on posttest scores, on gain scores, and on covariate-adjusted means, and the three analyses agree in direction and in magnitude. These results contribute to the growing body of evidence supporting student-centered instructional approaches in mathematics education and extend that literature by examining the integration of PBL and inquiry within a single framework rather than as competing alternatives.

The magnitude of the effect is consistent with previous meta-analytic research on student-centered teaching methods in mathematics. Moderate to large effects have been reported for problem-based, cooperative, and inquiry-based learning across multiple grade levels and mathematical topics, and the present result falls within the upper part of that range (AY Emanet & Kezer, 2021). The comparison with project-based instruction in elementary mathematics points the same way, since students taught through project work have been found to outperform peers taught conventionally, with particularly strong effects on problem solving and conceptual understanding (Lazić et al., 2021). A systematic review of problem-based learning in school mathematics helps to situate the design of the present study, because integrated forms of problem-based instruction were more frequent among the studies it identified than exclusive implementations of a single model, and mathematics achievement and problem solving were the outcomes most often assessed (Ayari et al., 2025). An effect of this size therefore does not stand alone as

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

an anomaly. It sits at the upper boundary of a distribution of effects that the literature has already documented, and the interpretive question is not whether the effect is real but which conditions produced it.

Several features of the model may explain its effectiveness. First, the model provided students with an authentic context for mathematical learning through the driving questions and real-world problems that framed each unit. When students see the practical relevance of fractions in contexts such as planning a class party or distributing resources, the mathematical concepts become more meaningful and memorable (Hmelo-Silver, 2004). Second, the structured inquiry cycles embedded within each project guided students through systematic processes of questioning, investigation, data analysis, and conclusion, which helped them develop deeper conceptual understanding rather than merely memorizing procedures (Margunayasa et al., 2021). The combination of authentic context and systematic investigation created a learning environment in which students could connect abstract fraction concepts to concrete applications, a process that is central to effective mathematics learning (Lerman, 1989). Third, the collaborative nature of the projects encouraged peer interaction and discussion, which has been shown to enhance mathematics learning through the sharing of strategies, the articulation of reasoning, and the negotiation of meaning (Setiana et al., 2020). These three elements, namely authentic context, systematic inquiry, and collaboration, worked synergistically in the integrated model, and their combined effect plausibly contributed to the achievement gains observed in the experimental group.

Connecting an effect of this size to classroom practice requires more than restating it. An effect of about one standard deviation means that a student at the median of the control distribution would be expected to reach roughly the eighty-fourth percentile of that distribution had the student been taught under the integrated model. Translated to the reporting scale used here, the same effect amounts to approximately eight points on a test scored from 0 to 100, which is the difference between a score just above 60 and a score just above 70. Two features of the implementation make that difference plausible. The first is the length of the unit. Each unit ran for two weeks and ended with a product, so students returned to the same fraction concept across ten sessions rather than meeting it once and moving on, and the product made visible to them the gap between what they understood and what they could not yet explain. The second is the position of the teacher. Facilitation through probing questions kept the inquiry guided rather than open, and that choice matters at this age, because fifth-grade students do not reliably generate productive questions about fractions without support (Margunayasa et al., 2021). What the effect size does not license is the claim that the model works regardless of conditions. Forty sessions of thirty-five minutes require a timetable that protects mathematics time, and the production of a poster, a model, or a written report requires materials and storage that not every primary school in the region can supply. Systematic reviews of project-based mathematics instruction reach a similar conclusion from the other direction, reporting that the factors influencing implementation are at least as decisive as the design of the model itself (Nguyen et al., 2024). The effect is therefore best read as conditional on the intensity of the implementation rather than as a property of the label attached to the model.

The findings are consistent with previous research on the effectiveness of inquiry-based approaches for elementary mathematics. Guided discovery learning has been shown to improve the mathematics achievement of fifth-grade students in Indonesia, and

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

the present study extends that finding by showing that embedding inquiry within a project-based framework can produce larger effects (Yurniwati & Hanum, 2016). Guided inquiry has also been found to reduce misconceptions among elementary students, and the integrated model in this study, which incorporated guided inquiry within project contexts, appears to have built on that benefit by helping students apply corrected understanding to authentic problems (Margunayasa et al., 2021). The advantage of combining inquiry with structured collaboration rather than relying on either alone receives support from a quasi-experimental study in which fourth-grade students taught through an instructional model built on collaborative and inquiry-based learning outperformed peers taught conventionally on analytical thinking and mathematical reasoning (Yu et al., 2024). The alignment of the present findings with these prior studies strengthens the case for adopting inquiry-oriented approaches in Indonesian elementary mathematics classrooms, where conventional instruction remains the predominant method (Siswadi et al., 2024).

The results also align with research on the motivational benefits of student-centered approaches, and the achievement gains observed here may be partly attributable to increased engagement. Problem-based learning has been found to increase student engagement in elementary mathematics (Anugraheni et al., 2025), engaging instructional approaches predict students' mathematics interest (Oppermann & Lazarides, 2021), and mathematics classrooms organized around projects report higher engagement alongside stronger collaboration and problem-solving capacity (Rehman et al., 2024). The integrated PBL-inquiry model provided multiple motivational affordances: the authenticity of the projects enhanced relevance, the inquiry process built confidence through successful investigations, and the collaborative work met students' need for social connection. The present study did not measure motivation, so this account remains an interpretation of the achievement pattern rather than a tested mechanism, and the distinction matters when the findings are read by teachers who are deciding whether the effort of redesigning a unit is justified.

The effectiveness of the integrated model relative to conventional instruction also supports broader calls for reforming mathematics education in Indonesia and similar contexts. The conventional approach, which emphasizes teacher explanation, worked examples, and individual practice, has been criticized for its limited capacity to develop higher-order thinking skills and conceptual understanding (Farhan et al., 2021). The results of this study suggest that even within the constraints of the Indonesian elementary school system, with its large class sizes and limited resources, the integrated PBL-inquiry model can produce meaningful improvements in mathematics achievement. This finding is encouraging given that the treatment was implemented over a relatively short period of eight weeks and covered only one mathematical topic, fractions. It also has a less comfortable implication. The reviews of project-based mathematics instruction make clear that implementation demands time, materials, and teacher support, and a model that depends on all three is easier to adopt in a well-resourced school than in the schools that most need the improvement (Nguyen et al., 2024). If the model were extended across the entire academic year and applied to multiple mathematical topics, the cumulative effects on achievement could be more substantial, provided that the conditions of implementation were protected rather than assumed.

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

Several limitations of this study should be acknowledged. First, the sample was limited to 76 fifth-grade students from two schools in Ende, which restricts the generalizability of the findings to other regions, grade levels, and school types in Indonesia. Second, the assignment of schools to treatment conditions was not fully randomized, as only two schools participated. While the pretest analysis confirmed baseline equivalence between the groups, the quasi-experimental design cannot entirely rule out the influence of school-level variables such as teacher quality and school climate. Third, the study examined only one mathematical topic, fractions, and the findings may not generalize to other areas of the mathematics curriculum. Fourth, the study did not include measures of potential mediating variables such as student motivation, engagement, or collaborative skills, which limits the ability to explain the mechanisms through which the integrated model produced its effects. Fifth, the achievement measure was developed by the researchers, so the scores are meaningful within the study but not directly comparable with external benchmarks of fraction competence.

Future research should address these limitations by employing fully randomized designs with larger and more diverse samples across multiple regions of Indonesia. Longitudinal studies that track students over an entire academic year or longer would provide evidence on the sustainability and cumulative effects of the integrated PBL-inquiry model. Research that incorporates measures of motivation, self-efficacy, and engagement alongside achievement measures would help clarify the mechanisms underlying the effectiveness of the model. Studies that examine the integrated model across different mathematical topics and at different grade levels would contribute to understanding the conditions under which the model is most effective. Finally, qualitative research employing classroom observations and teacher interviews would provide insight into the implementation processes and the difficulties that teachers face when adopting the integrated model, and that insight is what teacher training programs need in order to support the transition from conventional to student-centered instruction.

## CONCLUSION

**Fundamental Finding**: the integrated project-based learning and inquiry model improved elementary school students' mathematics achievement more than conventional instruction did. Students in the experimental group recorded higher posttest scores, larger learning gains, and higher covariate-adjusted means than students in the control group, and the effect was large under every specification used in the analysis. The result does not show that integration is superior in general. It shows that combining the authentic, product-oriented engagement of project-based learning with the structured investigation of guided inquiry produced an advantage that neither component was tested against separately. **Implication**: the findings support the adoption of the integrated PBL-inquiry model in elementary mathematics classrooms, particularly where teacher-centered instruction remains dominant. Teachers gain most from training that addresses the design of a driving question and the facilitation of inquiry cycles together, because the two are what distinguish the integrated model from a project assigned at the end of a conventional unit. Schools and policymakers carry the complementary obligation of protecting the mathematics time and the materials that the model requires, since an effect that depends on those conditions disappears when they are withdrawn. Curriculum designers may consider naming integration explicitly in guidance for topics that benefit from contextualized work. **Limitation**: the study was limited to 76 fifth-grade

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

students from two schools in Ende, which restricts generalizability. The quasi-experimental design precludes fully causal conclusions, only one mathematical topic was examined over eight weeks, no measures of mediating variables such as motivation or engagement were included, and the achievement test was developed by the researchers. **Future Research**:fully randomized designs with larger and more diverse samples across Indonesian regions are needed to confirm these findings. Longitudinal studies would assess the sustainability of the effect, research incorporating measures of motivation and engagement would clarify the mechanisms behind it, and replication across mathematical topics and grade levels would establish the conditions under which the integrated model is most effective.

## ACKNOWLEDGEMENTS

Acknowledgements of people, grants, funds, etc should be placed in a separate section not numbered at the very end of the paper.

## REFERENCES

Anugraheni, I., Purnomo, Y., & Ghufron, A. (2025). The effect of problem-based learning on student engagement in elementary mathematics learning. *Multidisciplinary Reviews*. https://doi.org/10.31893/multirev.2026310

AY Emanet, E., & Kezer, F. (2021). The effects of student-centered teaching methods used in mathematics courses on mathematics achievement, attitude, and anxiety. *Participatory Educational Research*, *8*(2), 240–259. https://doi.org/10.17275/per.21.38.8.2

Ayari, M. A., Sellami, A., Santhosh, M. E., Naji, K. K., Al-Ali, A., & Al-Hazbi, S. M. A. (2025). From problems to performance: A systematic review of problem-based learning in K-12 mathematics. *Frontiers in Education, 10*, Article 1731307. https://doi.org/10.3389/feduc.2025.1731307

Beswick, K. (2021). Inquiry-based approaches to mathematics learning, teaching, and mathematics education research. *Journal of Mathematics Teacher Education*, *24*, 123–137. https://doi.org/10.1007/s10857-021-09494-4

Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative* (Vol. 7). Prentice Hall Upper Saddle River, NJ.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Farhan, M., Satianingsih, R., & Yustitia, V. (2021). Problem based learning on literacy mathematics: Experimental study in elementary school. *Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang*, *5*(1), 118–129. https://doi.org/10.31331/medivesveteran.v5i1.1492

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Lazić, B., Knežević, J., & Maričić, S. (2021). The influence of project-based learning on student achievement in elementary mathematics education. *South African Journal of Education*, *41*(3), 1–10. https://doi.org/10.15700/saje.v41n3a1909

Lerman, S. (1989). Constructivism, mathematics and mathematics education. *Educational Studies in Mathematics*, *20*(2), 211–223. https://doi.org/10.1007/BF00579463

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 7, No. 6, November 2026
Page 1526-1538
© 2026 IJORER:
International Journal of Recent Educational Research

Lethulur, N., Juandi, D., & Dahlan, J. (2025). The effectiveness of discovery, inquiry, problem, and project-based learning in mathematics education: A systematic literature review. *Jurnal Pendidikan MIPA*, *26*(1), 268–279. https://doi.org/10.23960/jpmipa.v26i1.pp268-279

Margunayasa, I. G., Dantes, N., & Marhaeni, A. A. I. N. (2021). Reducing misconceptions of elementary school students through guided inquiry learning. *Jurnal Ilmiah Sekolah Dasar*, *5*(4), 722–730. https://doi.org/10.23887/jisd.v5i4.40388

Nguyen, H. T. M., Nguyen, G. T. C., Thai, L. T. H., Truong, D. T., & Nguyen, B. N. (2024). Teaching mathematics through project-based learning in K-12 schools: A systematic review of current practices, barriers, and future developments. *TEM Journal, 13*(3), 2054–2065. https://doi.org/10.18421/TEM133-33

OECD. (2023). *PISA 2022 results (Volume I and II): Country notes, Indonesia*. OECD Publishing. https://www.oecd.org/en/publications/2023/11/pisa-2022-results-volume-i-and-ii-country-notes_2fca04b9/indonesia_0e09c072.html

Oppermann, E., & Lazarides, R. (2021). Elementary school teachers' self-efficacy, student-perceived support and students' mathematics interest. *Teaching and Teacher Education*, *103*, 103351. https://doi.org/10.1016/j.tate.2021.103351

Rehman, N., Huang, X., Mahmood, A., & AlGerafi, M. A. M. (2024). Project-based learning as a catalyst for 21st-century skills and student engagement in the math classroom. *Heliyon, 10*(23), e39988. https://doi.org/10.1016/j.heliyon.2024.e39988

Setiana, D., Ili, L., & Rumasoreng, M. (2020). Relationship between cooperative learning method and students' mathematics learning achievement: A meta-analysis correlation. *Al-Jabar: Jurnal Pendidikan Matematika*, *11*(1), 39–50. https://doi.org/10.24042/ajpm.v11i1.6620

Siswadi, S., Tiwan, T., & Dharin, A. (2024). Project based learning (PjBL) for improving elementary school mathematics learning outcomes in Banyumas Regency, Indonesia. *Educational Administration: Theory and Practice*, *30*(4). https://doi.org/10.53555/kuey.v30i4.691

Turgut, S., & Turgut, İ. (2018). The effects of cooperative learning on mathematics achievement in Turkey: A meta-analysis study. *International Journal of Instruction*, *11*(3), 705–728. https://doi.org/10.12973/iji.2018.11345a

Yu, S., Jantharajit, N., & Srikhao, S. (2024). An instructional approach in mathematics learning for fourth-grade students based on collaborative learning and inquiry-based learning. *Asian Journal of Contemporary Education, 8*(2), 77–92. https://doi.org/10.55493/5052.v8i2.5099

Yurniwati, Y., & Hanum, L. (2016). Improving mathematics achievement of Indonesian 5th grade students through guided discovery learning. *Journal on Mathematics Education*, *8*(1), 77–84. https://doi.org/10.22342/jme.8.1.3209.77-84

***Marselina Wali (Corresponding Author)**
Universitas Flores
Jalan Sam Ratulangi, Kelurahan Paupire, Kabupaten Ende, Nusa Tenggara Timur
Email: Marselinawali0103@gmail.com

**Agnes Remi Rando**
Universitas Flores
Jalan Sam Ratulangi, Kelurahan Paupire, Kabupaten Ende, Nusa Tenggara Timur
Email: agnes.remi.rando@gmail.com