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Effect of Project-Based Learning with an Ethnomathematics Approach on Junior High School Students' Mathematical Problem-Solving Ability

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ABSTRACT

Mathematical problem-solving is essential, yet instruction often emphasizes rote learning and fails to connect mathematics to real-life contexts; Project-Based Learning (PjBL) with an ethnomathematics approach may bridge this gap, though evidence at the junior high school level remains limited. This study examines whether PjBL with an ethnomathematics approach improves students' mathematical problem-solving ability compared to direct instruction and whether students achieve the mastery criterion. A quasi-experimental nonequivalent pretest-posttest control group design was used. Random sampling assigned class VIII-2 as the experimental group and VIII-6 as the control. Data were analyzed using normality, homogeneity, t-tests, and N-gain. The experimental group's mean post-test score (78.00) was significantly higher than the control group's (68.26) and exceeded the mastery criterion of 75, although only 20 of 30 students reached it. The N-gain score was 0.53, indicating moderate improvement. In conclusion, PjBL with an ethnomathematics approach shows potential but yields moderate and uneven benefits. Cultural contexts should function as sources of mathematical problems within project stages, with teacher support at the stages of understanding problems, designing strategies, and reflecting on solutions. Future research should test this integration in diverse settings with longer interventions.

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Introduction

Problem-solving ability is a key competency in mathematics education. The National Council of Teachers of Mathematics (NCTM) identifies problem-solving—alongside connections, reasoning, communication, and representation—as a fundamental skill to be developed through mathematics instruction (NCTM, 2000; Sumartini, 2016). This ability is crucial because mathematics education should not merely focus on mastering procedures and replicating examples; rather, it must equip students to understand situations, select strategies, execute solutions, and evaluate the results obtained. Within Polya's (1973) framework, the problem-solving process comprises four stages: understanding the problem, devising a plan, carrying out the plan, and looking back (reviewing the results). Consistent with this, problem-solving also entails the ability to identify relevant information, formulate mathematical models, apply solution strategies, and interpret results (Lestari & Yudhanegara, 2015). Thus, problem-solving represents a cognitive process that is more complex than the mere application of routine algorithms.

Despite its importance, mathematical problem-solving remains a challenge for students (Rahman et al., 2018). Students often encounter difficulties when facing problems that differ from the examples provided by the teacher—particularly contextual problems that require identifying information, selecting strategies, and developing solution procedures. Havill & Havill (2020) emphasize that problem-solving is defined not merely by the final answer, but also by the processes students use to understand the problem, plan a strategy, execute the solution, and evaluate it. This suggests that instruction placing excessive emphasis on formula memorization and procedural imitation may limit students' opportunities to develop independent problem-solving skills.

Similar issues were observed during a preliminary study involving eighth-grade students at SMP Negeri 1 Kaliori. Interviews with the mathematics teacher and observations of students' work revealed that some students struggled to identify given and required information, comprehend contextual problems, and determine appropriate strategies when faced with problems unlike previous examples. Additionally, some students tended to proceed directly to calculations without first analyzing the problem's structure. These preliminary findings indicate a need for instruction that affords students greater scope to explore problems, devise strategies, test solutions, and connect mathematics to situations that are meaningful to them.

The selection of a learning model is one factor that can facilitate the development of these skills (Yuliasari, 2017). One relevant model is Project-Based Learning (PjBL). PjBL engages students in learning activities centered on problem-solving and the development of a project or product. This model provides students with opportunities to address contextual problems, conduct investigations, make decisions, and produce work based on their learning process (Guo et al., 2020). Niswara et al. (2019) also emphasize that PjBL can foster student independence in problem-solving through activities that result in tangible projects or products. These characteristics make PjBL relevant for problem-oriented mathematics learning.

The implementation of PjBL involves a process of defining a driving question, planning the project, creating a schedule, monitoring project progress, assessing outcomes, and evaluating the learning experience (Wajdi, 2017). These stages provide students with the opportunity to understand the problem before determining strategies, discussing alternative solutions, executing the plan, presenting results, and reflecting on the process undertaken. This structure aligns with Polya's (1973) problem-solving stages. Furthermore, PjBL is reported to have the potential to foster problem-solving skills, independent learning, and a sense of responsibility, while offering broader learning opportunities (Azizah & Wardani, 2019). Autonomy in setting goals, leveraging learning experiences, and evaluating the learning process also constitutes a relevant component of project-based learning activities (Muslim, 2017).

However, merely assigning a project does not guarantee that the problems students face will resonate with their own experiences. The context employed in a project is crucial, as problem-solving requires situations that students can comprehend and find meaningful. In mathematics education, cultural contexts can be utilized to bridge formal concepts and everyday life experiences through an ethnomathematical approach. Mathematics possesses social,

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cultural, and historical dimensions, given that various mathematical ideas evolve within human activities and societies (Herzon et al., 2018; Ikhsan et al., 2017). Ethnomathematics, therefore, views mathematics in relation to the practices, activities, and knowledge that develop within specific cultural groups (Azizah & Fitrianawati, 2020; Vitantri, 2017).

Integrating cultural contexts into instruction can align mathematical activities more closely with students' experiences. Imswatama & Lukman (2018) and Cahyadi et al. (2020) demonstrate that culturally linked mathematics instruction enhances engagement, as students not only encounter formal mathematical knowledge but also recognize the connections between mathematics and the culture within their environment. The ethnomathematics approach is also considered compatible with instruction that fosters scientific inquiry among students through observation, exploration, and the resolution of contextual problems (Safitri et al., 2020). Consequently, ethnomathematical contexts offer the potential to provide authentic problems that can serve as starting points for project-based activities.

Conceptually, the integration of PjBL and ethnomathematics is strongly linked to problem-solving skills. PjBL provides a structure for problem-solving activities through projects, while ethnomathematics offers problem contexts that are closely related to students' lives and cultures. When working on culture-based projects, students must identify problems, connect contextual information with mathematical concepts, devise strategies, generate solutions, present results, and evaluate the processes undertaken. These activities align with problem-solving indicators that emphasize knowledge construction through problems, the use of diverse strategies, problem-solving across various contexts, and reflection on the solution process (NCTM, 2000)

Although various prior studies have supported PjBL as a problem-oriented model (Guo et al., 2020; Niswara et al., 2019; Azizah & Wardani, 2019) and ethnomathematics as an approach linking mathematics to students' cultural contexts (Imswatama & Lukman, 2018; Vitantri, 2017; Azizah & Fitrianawati, 2020; Cahyadi et al., 2020), the existing evidence largely establishes a foundation for each approach in isolation. The literature has not sufficiently clarified whether integrating a project-based learning structure with an ethnomathematical context yields superior mathematical problem-solving skills compared to direct instruction, particularly among junior high school students. Beyond inter-group comparisons, it is also crucial to determine whether students' abilities following such instruction meet established learning achievement criteria. Addressing both aspects ensures that instructional effectiveness is evaluated not only through relative differences against a comparison group but also through the attainment of expected competencies.

Based on this gap, this study aims to examine the effect of Project-Based Learning (PjBL) using an ethnomathematics approach on the mathematical problem-solving skills of eighth-grade students. Specifically, the study investigates whether the mathematical problem-solving skills of students receiving PjBL with an ethnomathematics approach are superior to those of students receiving direct instruction, and whether the skills of students in the PjBL-ethnomathematics group meet the Learning Objective Achievement Criteria. Thus, this study is expected to provide empirical evidence regarding the effectiveness of integrating PjBL and ethnomathematics in developing students' mathematical problem-solving skills.

Project-Based Learning through an Ethnomathematics Approach and Mathematical Problem-Solving Ability

Project-Based Learning (PjBL) utilizing an ethnomathematical approach creates a learning environment where students engage in mathematical problem-solving through project-based activities linked to cultural contexts. This integration is relevant to mathematical problem-solving skills, as it requires students to interpret contextual information, formulate solution strategies, apply mathematical concepts, communicate their reasoning, and evaluate the resulting solutions. In geometry instruction, for instance, cultural objects can serve as authentic contexts for exploring concepts related to cubes and rectangular prisms, including their surface area and volume. Such contexts enable students to connect mathematical concepts with objects that are closer to their own experiences.

The connection between PjBL and mathematical problem-solving skills can also be examined through its instructional stages. During the stage of defining the fundamental question, students encounter a contextual problem that requires them to observe, interpret, and identify relevant mathematical information. In the project planning stage, students collaborate to determine procedures, assign tasks, identify necessary resources, and formulate solution strategies. The scheduling stage trains students to organize the sequence and timing of the work, while the project monitoring stage offers opportunities to identify obstacles, review strategies, and refine the solution process. During the project assessment stage, students present and justify their solutions, respond to questions, and evaluate alternative solutions from other groups. Finally, the project evaluation stage encourages students to reflect on both the process and the outcomes of their work. This sequence of activities provides students with opportunities to understand the problem, devise a plan, implement strategies, and review the resulting solutions.

The ethnomathematics approach strengthens this process by situating mathematical problems within a cultural context that is meaningful to students. Mathematics is positioned not merely as symbolic and abstract knowledge, but also as knowledge found in various activities, artifacts, and cultural practices. Thus, the cultural context serves as a source of mathematical problems, while Project-Based Learning (PjBL) provides a learning structure that enables students to investigate and solve those problems. The integration of the two creates a learning flow that moves from cultural context to problem formulation, project-based investigation, mathematical reasoning, solution development, and finally, reflection.

A number of previous studies provide empirical support for various components of this integration. Mahendra (2017) demonstrated that ethnomathematics-infused Project-Based Learning (PjBL) offers advantages over conventional instruction. Hesti (2017) found that students taught using PjBL exhibited higher mathematical creative thinking skills compared to those receiving conventional instruction. Endra & Zaenuri (2017) also showed that the problem-solving skills of students participating in ethnomathematics-infused Project-Based Learning were superior to those of students taught via discussion methods using a scientific approach. These findings indicate that project-based learning incorporating meaningful contexts can support the development of students' mathematical thinking skills.

Empirical support is also found when PjBL and ethnomathematics are examined separately. Imswatama & Lukman (2018) demonstrated that students using ethnomathematics-based instructional materials possessed superior mathematical problem-solving skills compared to those who did not. Hindriyanto et al. (2019) found that the problem-solving skills of students who experienced Project-Based Learning were better than those of students who did not receive such instruction. Consistent results were reported by Azis & Herianto (2021), showing that the implementation of Project-Based Learning could enhance the mathematical problem-solving skills of junior high school students. In a broader context, Dwi & Sofian (2023) also identified PjBL as a relevant alternative for mathematics instruction within the implementation of the *Kurikulum Merdeka* (Independent Curriculum).

Other studies reinforce the importance of instructional materials and learning environments that align with the characteristics of this approach. Ristiningsih et al. (2021) demonstrated that students learning with the support of e-modules could meet established

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minimum mastery criteria. Amelia et al. (2021) highlighted the potential of using Project-Based Learning materials in mathematics instruction, while Bintoro et al. (2021) found that ethnomathematics-based mobile modules met validity criteria and were suitable for use in learning. Overall, these findings indicate that project-based learning, mathematics activities linked to culture, and appropriate instructional materials have the potential to create a more contextual and meaningful mathematics learning experience.

However, the available evidence does not yet provide a fully integrated explanation regarding the impact of PjBL—utilizing an ethnomathematical approach—on students' mathematical problem-solving abilities. Some studies emphasize PjBL, others focus on ethnomathematics or supporting instructional materials, while some examine mathematical skills other than problem-solving. Research combining PjBL and ethnomathematics also requires further evidence to determine whether this integration yields superior mathematical problem-solving skills compared to direct instruction while simultaneously enabling students to meet established learning achievement criteria. Both aspects are crucial, as relative superiority over a comparison group and the attainment of learning standards represent two distinct forms of evidence for evaluating instructional effectiveness.

Based on this framework, the study views PjBL and ethnomathematics as two complementary components of learning. PjBL provides the process students use to investigate and solve problems, while ethnomathematics offers the cultural context that serves as the source of those problems. Integrating the two is expected to provide students with opportunities to understand mathematical situations, select and apply strategies, communicate solutions, and reflect on the accuracy of the processes and results obtained. This framework serves as the basis for examining the impact of Project-Based Learning—utilizing an ethnomathematical approach—on the mathematical problem-solving abilities of junior high school students.

Method

Type of Research

This study employs a quantitative approach with a quasi-experimental design. Specifically, it utilizes a non-equivalent pretest-posttest control group design, involving one experimental group and one control group without individual randomization of participants (Sugiyono, 2016). This design was selected because the study was conducted using pre-existing classes. The experimental group received instruction based on Project-Based Learning (PjBL) incorporating an ethnomathematical approach, whereas the control group received direct instruction. Prior to the intervention, both groups were administered a pretest to assess their initial mathematical problem-solving abilities. Following the intervention, both groups took a posttest to measure their mathematical problem-solving abilities after the instruction. The research design can be represented as Table 1.

Table 1. Research Design

Group	Pretest	Intervention	Posttest
Experimental Group	O_1	X	O_2

Control Group	O_1	C	O_2

Note:
O_1 = pretest
O_2 = posttest
X = Project-Based Learning through an ethnomathematics approach
C = direct instruction

Participants

The research participants were eighth-grade students at SMP Negeri 1 Kaliori. The study population comprised all eighth-grade students at the school. The sample was selected using purposive sampling—a method involving sample selection based on considerations related to the study's objectives and characteristics (Lestari & Yudhanegara, 2015). Class selection was based on three key criteria: the students followed the same curriculum, received instruction from the same teacher, and possessed relatively comparable prior ability levels. Based on these considerations, classes VIII-7 and VIII-8 were selected as the research sample. Class VIII-7 was designated as the experimental group, while class VIII-8 served as the control group. Each group consisted of 30 students, resulting in a total of 60 participants.

Instruments

Mathematical problem-solving ability was measured using an essay-type test covering the surface area and volume of cubes and rectangular prisms. The instrument consisted of six problems designed to reveal students' solution processes, ensuring that assessment was based not only on the final answer but also on the strategies and steps employed. Each problem encompassed four problem-solving aspects: understanding the problem, planning the solution, executing the plan, and reviewing the results. The instrument was administered as both a pretest and a posttest for both groups. Prior to the main study, the problems underwent a pilot test to evaluate their validity, reliability, discrimination power, and difficulty level. The empirical validity of each item was analyzed using the Pearson product-moment correlation by comparing individual item scores against the total score (Lestari & Yudhanegara, 2015; Wanabuliandari & Ulya, 2018). With a critical value of $r = 0.374$, the validity coefficients for the six items were 0.89, 0.86, 0.78, 0.71, 0.79, and 0.62, respectively. Thus, all items met the validity criteria established for the study. The instrument's internal consistency was evaluated using Cronbach's alpha (Lestari & Yudhanegara, 2015). Additionally, the quality of each problem was analyzed based on discrimination power and difficulty level. The discrimination power analysis yielded values ranging from 0.39 to 0.51. Difficulty level analysis was conducted by comparing the mean score of each item with the ideal maximum score to ensure the instrument possessed an appropriate level of difficulty.

Procedures

The research was conducted in three main stages: pretest, instructional intervention, and posttest. In the initial stage, both the experimental and control groups were administered the same pretest to gather data on the students' baseline mathematical problem-solving abilities. The pretest results were also used to verify the equivalence of the two groups' initial proficiency

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levels. During the intervention stage, the experimental group received instruction using Project-Based Learning (PjBL) integrated with an ethnomathematical approach. Project problems and activities were developed by linking the topics of cubes and rectangular prisms to relevant cultural contexts—such as using cultural objects like the Kudus Tower as a basis for identifying and exploring geometric concepts. The intervention followed the six stages of PjBL: determining the fundamental question, designing the project plan, creating a schedule, monitoring project progress, assessing project outcomes, and evaluating the project results.In the stage of determining the fundamental question, the teacher presented cultural objects or problems related to the concepts of cubes and rectangular prisms. Students observed the context, identified relevant information, and solved the initial problem provided. Subsequently, students worked in groups to design the project, assign tasks, determine necessary tools and materials, and select strategies for project completion. During the implementation stage, students and the teacher established a schedule for completing the project. The teacher monitored each group's progress, while students reported their advancements and any challenges encountered during the work. Once the projects were completed, each group presented its work. Other groups were given the opportunity to ask questions, provide feedback, or propose alternative solutions. In the final stage, the teacher and students evaluated the project outcomes and reflected on the problem-solving process they had undertaken. The control group studied the same material using direct instruction without ethnomathematics-based project activities. Upon completion of the learning process, both groups were administered a post-test to measure their mathematical problem-solving abilities following the intervention.

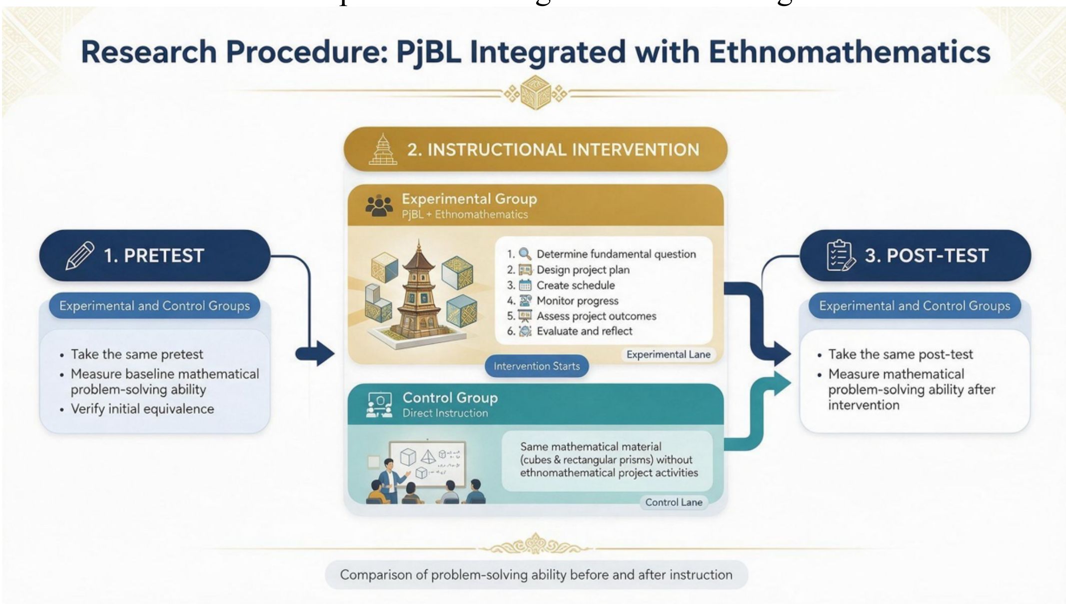

Figure 1. Research Procedures

Data Analysis

Data analysis was conducted using SPSS software. The analysis encompassed both descriptive and inferential statistics. Descriptive statistics were used to characterize the mathematical problem-solving ability scores from the pretest and posttest by calculating means and standard deviations. Prior to hypothesis testing, the data distribution was assessed using the Shapiro-Wilk test, while the equality of variances between groups was examined via a test of homogeneity. All statistical tests were conducted at a 5% significance level ($\alpha = 0.05$). The initial abilities of both groups were analyzed using pretest scores to ensure that the experimental and control groups possessed comparable baseline capabilities. Subsequently, the primary hypothesis regarding the difference in mathematical problem-solving ability following instruction was tested using an independent-samples t-test on the posttest scores of the experimental and control groups. The hypothesis tested was:

$$H_0: \mu E \leq \mu C$$
$$H_1: \mu E > \mu C$$

where μE represents the mean mathematical problem-solving ability of the group receiving PjBL via an ethnomathematics approach, and μC represents the mean of the group receiving direct instruction.

To determine whether the mathematical problem-solving ability of students in the experimental group met the Learning Objective Achievement Criteria (KKTP), a one-sample t-test was conducted using a reference value of 75. The hypotheses tested were:

$$H_0: \mu E \leq 75$$
$$H_1: \mu E > 75$$

In addition to the primary analysis, the improvement in students' mathematical problem-solving skills was analyzed using the normalized gain (N-Gain), calculated based on the change between pretest and posttest scores. N-Gain values were categorized as high ($g \geq 0.70$), medium ($0.30 < g < 0.70$), and low ($g \leq 0.30$) in accordance with the criteria applied in the study (Lestari & Yudhanegara, 2015). The N-Gain analysis served as a supplementary analysis to illustrate the magnitude of the improvement in problem-solving skills within each group.

Results

Implementation Results

The research was conducted in May 2026 at SMP Negeri 1 Kaliori, involving two Grade VIII classes. Class VIII-2 served as the experimental group and received instruction using Project-Based Learning (PjBL) via an ethnomathematics approach, while Class VIII-6 served as the control group and received direct instruction. Each group consisted of 30 students. The research procedure consisted of a pretest, the instructional phase, and a posttest. A pretest was administered to both groups prior to instruction to assess the students' initial mathematical problem-solving abilities. According to the documented research schedule, the core instructional activities were conducted over two sessions, followed by the posttest. The subject matter covered for both groups was the surface area and volume of cubes and rectangular prisms.

In the experimental group, instruction integrated the stages of Project-Based Learning (PjBL) with an ethnomathematical context. Initially, students were introduced to objects and problems related to culture as well as the concepts of cubes and rectangular prisms. Students then identified problems, discussed solution strategies, and worked on assigned tasks in groups. During the project activities, students developed plans, discussed solutions, and communicated their findings. The teacher provided guidance and monitored the project completion process.

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The resulting work was subsequently presented and discussed collectively, allowing students to explain and evaluate the solution strategies they had employed.

In the control group, instruction was conducted using a direct instruction approach. The teacher explained the concepts of surface area and volume for cubes and rectangular prisms, provided examples and practice problems, and gave students the opportunity to solve problems at the board. The teacher and students then discussed the solutions provided. Upon completion of the instructional sequence, both groups took a posttest using the same instrument for assessing mathematical problem-solving ability.

Figure 2. Research Implementation

Descriptive results

Students' mathematical problem-solving abilities were analyzed based on pretest and posttest results from the experimental and control groups. A summary of the measurement results is presented in Table 2.

Table 2. Descriptive Statistics of Mathematical Problem-Solving Ability

Statistic	Experiment Pretest	Control Pretest	Experiment Posttest	Control Posttest
Number of students	30	30	30	30
Minimum score	24	16	70	38
Maximum score	80	76	92	84
Average	52.93	50.60	78.00	68.26
Students obtaining grades ≥ 75	1	1	20	7
Students obtaining grades < 75	29	29	10	23

In the pretest, the mean mathematical problem-solving ability was 52.93 for the experimental group and 50.60 for the control group, a difference of only 2.33 points. The initial distribution of achievement levels was also relatively similar; only one student out of 30 in each group scored at least 75. Following instruction, the experimental group's mean posttest score rose to 78.00, while the control group reached 68.26, resulting in a 9.74-point difference favoring the experimental group. The minimum score in the experimental group increased from 24 to 70, whereas in the control group, it rose from 16 to 38. Twenty out of 30 students (approximately 66.7%) in the experimental group achieved a score of at least 75, compared to only 7 out of 30 students (approximately 23.3%) in the control group. Analysis of the improvement in the experimental group yielded an N-Gain score of 0.53, based on the shift in the mean score from 52.93 (pretest) to 78.00 (posttest); this value falls within the moderate category. Descriptively, these results indicate an improvement in mathematical problem-solving ability after students participated in PjBL using an ethnomathematics approach.

Inferential Results

Prior to testing the main hypothesis, an analysis of the initial abilities of both groups was conducted. A normality test on the pretest scores yielded significance values of 0.200 for the experimental group and 0.174 for the control group. Since both values exceeded 0.05, the pretest data met the assumption of normality. The homogeneity test yielded a significance value of 0.575, indicating that the variances of the two groups could be considered homogeneous. Furthermore, an independent-samples t-test on the pretest scores resulted in $p = 0.481$. Thus, there was no significant difference between the initial abilities of the experimental group and the control group.

Table 3. Initial Proficiency Test Results

Testing	Experiment	Control	p	Decision
Pretest Normality	0.200	0.174		Normal
Variance Homogeneity			0.575	Homogeneous
Pretest Mean Difference			0.481	Not significant

Assumption testing was also conducted on the posttest data. The normality test results showed significance values of 0.200 for the experimental group and 0.063 for the control group; both values exceeded 0.05. The homogeneity test yielded a p-value of 0.062. Thus, the posttest data met the assumptions of normality and homogeneity required for the independent-samples t-test. The first hypothesis examined whether the mathematical problem-solving ability of students receiving PjBL via an ethnomathematics approach was higher than that of students receiving direct instruction. The mean posttest score was 78.00 for the experimental group and 68.26 for the control group. The independent-samples t-test results indicated a significant difference between the two groups ($p < 0.001$). Since the mean score of the experimental group was higher than that of the control group, the results demonstrate that students receiving PjBL via an ethnomathematics approach possessed significantly higher mathematical problem-solving abilities compared to students receiving direct instruction.

Table 4. Hypothesis Testing Results

Testing	Mean	Comparison Value	p	Result
Experiment vs. control	78.00 vs. 68.26		< 0.001	Significantly different
Experiment group vs. score 75	78.00	75	0.004[1]	Significantly higher

[1] One-tailed p-value based on a two-tailed p-value of 0.008.

The second hypothesis tested whether the mean mathematical problem-solving ability of students in the experimental group exceeded the established criterion score of 75. The experimental group's posttest mean was 78.00. The one-sample t-test yielded a two-tailed p-value of 0.008. Since the research hypothesis was directional and the empirical mean was above 75, the one-tailed p-value was 0.004. These results indicate that the mean mathematical problem-solving ability of students receiving PjBL via an ethnomathematics approach was significantly higher than 75 ($p = 0.004$). Overall, the inferential results reveal two key findings. First, the mathematical problem-solving ability of students receiving PjBL via an ethnomathematics approach was significantly higher than that of the group receiving direct

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instruction. Second, the mean mathematical problem-solving ability of the experimental group exceeded the established achievement benchmark of 75.

Discussion

The Effect of PjBL Using an Ethnomathematical Approach on Mathematical Problem-Solving Ability

The study's key findings indicate that students taught using Project-Based Learning (PjBL) with an ethnomathematics approach achieved higher mathematical problem-solving skills compared to those receiving direct instruction. The experimental group's mean post-test score was 78.00, whereas the control group's was 68.26; this difference was statistically significant. These findings suggest that integrating project-based activities within a cultural context creates a learning environment more conducive to developing mathematical problem-solving skills than instruction centered on explanations and routine exercises. This advantage can be attributed to the nature of PjBL, which positions students as the primary agents in the problem-solving process. Rather than merely receiving solution procedures from the teacher, students are confronted with a problem, formulate plans, determine strategies, execute the project, communicate results, and evaluate the process undertaken. These activities are directly linked to mathematical problem-solving, as students must comprehend available information, identify relationships between problem elements, select appropriate procedures, and verify their solutions. Thus, the improvement in problem-solving skills stems not simply from the presence of a project task, but from the students' active engagement in the cognitive processes involved throughout the project's execution.

Group work within PjBL also creates opportunities for students to compare strategies, articulate mathematical reasoning, and evaluate solutions proposed by other group members. Such interactions can assist students when their initial strategies fail to yield a correct solution. These findings align with Nurfitriyanti (2016), who reported that students participating in PjBL demonstrated superior mathematical problem-solving skills compared to those in the control group. Nurfitriyanti (2016) attributed this outcome to the collaborative nature of project work, which enables students to exchange knowledge and discuss alternative solutions. The ethnomathematics approach reinforces these characteristics by presenting problems rooted in contexts closer to the students' own experiences. Incorporating cultural objects into problems involving cubes and rectangular prisms allows students to link formal mathematical representations with objects they recognize within their social and cultural environments. In the context of problem-solving, this contextual familiarity can help students grasp the problem situation before translating it into mathematical concepts and procedures. This is crucial because difficulties in problem-solving do not always stem from an inability to perform calculations; they can also arise when students fail to understand the situation or identify relevant information.

This explanation is consistent with the findings of Prabawa & Zaenuri (2017), who demonstrated that ethnomathematical contexts help students understand mathematical problems by linking them to local culture. Similarly, Imswatama & Lukman (2018) found that students using ethnomathematics-based instructional materials exhibited better mathematical problem-solving skills than those who did not. These findings suggest that the contribution of ethnomathematics in this study lies in providing a meaningful context for problem-solving activities, while PjBL provides the activity structure that enables students to explore that context systematically. The results of this study are consistent with those of Hindriyanto et al. (2019) and Azis & Herianto (2021), showing that students taught using PjBL demonstrated superior problem-solving skills compared to the comparison group. However, this study offers a more specific context, as PjBL was not implemented in isolation but was integrated with an ethnomathematical approach. This integration is significant because PjBL and ethnomathematics serve distinct yet complementary functions: PjBL structures the processes of investigation and problem-solving, while ethnomathematics provides the cultural context that serves as the source of mathematical problems. Consequently, the study's findings are best understood as the outcome of the interaction between the project-based learning structure and the use of cultural context, rather than as the effect of either component in isolation. Nevertheless, these results must be interpreted in light of the study's design. A quasi-experimental design utilizing pre-existing classes was employed; thus, differences in outcomes cannot be attributed solely to the intervention without considering the potential influence of class characteristics or other instructional factors. However, the absence of significant differences in baseline abilities between the two groups supports the conclusion that the experimental and control groups started from relatively comparable conditions prior to the intervention.

Achievement of Mathematical Problem-Solving Ability

The second finding indicates that the experimental group's mean post-test score of 78.00 was statistically higher than the established criterion score of 75. This result provides evidence that, as a group, students who engaged in Project-Based Learning (PjBL) via an ethnomathematics approach were able to surpass the learning achievement criteria used in the study. This achievement can be attributed to the opportunities PjBL affords students to repeatedly apply mathematical concepts to problem-solving. Rather than merely completing exercises after receiving an explanation, students utilize mathematical knowledge while designing and executing project activities. This process reinforces the connection between conceptual understanding and its application in problem-solving contexts. Discussion activities also provide students with opportunities to test their strategies through peer feedback and teacher evaluation.

These results align with the findings of Rose & Prasetya (2014), which indicate that project-based learning can facilitate the attainment of learning criteria. Nurfitriyanti (2016) also reported that project-based learning offers students opportunities to exchange ideas and strategies when solving contextual problems. Regarding the use of learning resources, Amelia et al. (2021) demonstrated that media-supported PjBL helps students comprehend the material and engage in more independent learning. However, the group's average achievement does not imply that every student met the established criteria. Of the 30 students in the experimental group, 20 (approximately 66.7%) scored at least 75, while 10 (approximately 33.3%) scored below that mark. This finding is significant as it demonstrates that the learning impact was not uniform across all students. In other words, while PjBL utilizing an ethnomathematical approach yielded positive results at the group level, some students still required additional support to attain the expected level of competence. These individual differences indicate that implementing PjBL through ethnomathematics still necessitates attention to students' prior knowledge, their ability to comprehend contextual problems, their contributions within the group, and the support provided by the teacher during the project. Therefore, an average score exceeding 75 should be interpreted as evidence of success at the aggregate level, rather than an indication that all students achieved the same level of mastery.

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Enhancement of Mathematical Problem-Solving Skills

The N-Gain analysis yielded a value of 0.53 for the experimental group, placing it in the moderate category. These results indicate an improvement in mathematical problem-solving skills, with the average score rising from 52.93 in the pretest to 78.00 following the students' participation in PjBL (Project-Based Learning) utilizing an ethnomathematical approach. These findings complement the inter-group comparison by demonstrating the shift in the experimental group's capabilities from the pre-intervention to the post-intervention stage. This improvement can be attributed to the problem-solving experiences provided during instruction. Students engaged with problems linked to cultural contexts, requiring them to interpret the problems, select strategies, collaborate with group members, and both present and evaluate their results. This process offered opportunities to apply problem-solving skills repeatedly within contexts that differed from standard procedural exercises.

These findings align with Wanabuliandari et al. (2020), who demonstrated that the use of ethnomathematics-based learning can enhance mathematical problem-solving skills, as environmental and cultural contexts help students grasp mathematical situations more concretely. Rose & Prasetya (2014) also showed that project-based activities provide students with opportunities to engage directly in problem-solving. Thus, the improvement observed in this study can be explained by two complementary mechanisms: the contextualization of problems through ethnomathematics and active engagement in the solution process via PjBL. However, the N-Gain score of 0.53—falling within the moderate category—indicates that the improvement has not yet reached a high level. This result is important for avoiding an overestimation of the intervention's effectiveness. While PjBL utilizing an ethnomathematics approach yields significant improvement, there remains room to optimize project design, intervention duration, support during group work, and the variety of problems employed. The relatively limited duration of the intervention may also be a factor constraining the extent of the change in students' abilities.

Integration of Findings and Learning Implications

Overall, the three research results demonstrate a consistent pattern. The PjBL group utilizing an ethnomathematics approach achieved a higher average post-test score compared to the direct instruction group; the experimental group's average exceeded the criterion score of 75, and the improvement from pre-test to post-test fell within the moderate category. These three findings provide evidence from different perspectives regarding the potential of integrating PjBL and ethnomathematics to support mathematical problem-solving skills. The research findings also indicate that the effectiveness of the instruction does not stem solely from assigning projects or incorporating cultural elements. Instructional impact is more likely to emerge when a cultural context serves as the source of mathematical problems and the PjBL stages provide the structure for investigating and solving those problems. In this configuration, students progress through a sequence of understanding the context, identifying mathematical information, planning a solution, implementing strategies, communicating results, and engaging in reflection.

Consequently, teachers employing PjBL via an ethnomathematical approach must ensure that the selected cultural objects bear a clear mathematical connection to the concepts being studied. Project activities should be designed so that students genuinely engage in the problem-solving process rather than merely producing an output. Elements such as the questions posed, the allocation of group tasks, monitoring processes, presentations, and reflections must all be geared toward fostering student reasoning in understanding and solving problems. These findings reinforce the view that integrating PjBL with ethnomathematics holds the potential to create mathematics learning that is more contextual and problem-solving oriented. However, the research results are best interpreted as evidence of an association with improved outcomes within this specific research context, rather than as a basis for claiming that the approach will invariably yield the same effects across all students, subject matter, and school settings.

Conclusion

This study demonstrates that the implementation of Project-Based Learning (PjBL) using an ethnomathematics approach is associated with improved mathematical problem-solving skills among eighth-grade students at SMP Negeri 1 Kaliori regarding the surface area and volume of cubes and rectangular prisms. Students in the experimental group achieved a mean post-test score of 78.00—higher than the mean of 68.26 achieved by the group receiving direct instruction—with the difference being statistically significant. These results indicate that project-based learning incorporating cultural contexts can create conditions that better support students in understanding problems, planning strategies, executing solutions, and evaluating outcomes. The experimental group's mean mathematical problem-solving score also significantly exceeded the established mastery criterion of 75. However, this achievement must be viewed at the group level, as 20 out of 30 students scored at least 75, while 10 students remained below that threshold. Furthermore, the improvement from pre-test to post-test yielded an N-Gain of 0.53, placing it in the moderate category. Thus, PjBL utilizing an ethnomathematics approach shows potential for supporting mathematical problem-solving skills, although the level of improvement was not high, and the learning benefits were not uniform across all students. The research findings underscore the importance of functionally integrating the structure of PjBL activities with ethnomathematical contexts. Cultural contexts should serve not merely as illustrations but as sources of mathematical problems to be investigated throughout the project stages. During implementation, teachers need to provide support—particularly during the stages of problem comprehension, strategy design, and solution reflection—to ensure every student has ample opportunity to engage in the problem-solving process. Future research could examine this integration across different subject matter and cultural contexts, employ longer intervention periods, and involve more diverse samples and schools to gather more robust evidence regarding the consistency of the approach's effectiveness.

Conflict of Interest

The authors declare no conflict of interest.

Auhor Contributions

S.E.K. contributed to the development of the research concept, data collection, data analysis, conducting the research, and writing the article. S and R.R. contributed to supervising the research, providing guidance on the research methodology, and refining the content and language of the article. All authors have read and approved the final version of this article for publication. The distribution of contributions to the conceptualization, writing, and revision of this research is as follows: S.E.K.: 45%, R.R. : 30%, and S.: 25%.

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Data Availability Statement

The authors state that the data supporting the findings of this study can be obtained from the author [S.E.K.], upon reasonable request.

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