Project-Based Learning Based on Papuan Local Wisdom: Its Impact on Collaboration Ability and Understanding of the Concept of Two-Dimensional Shapes

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ABSTRACT

The low level of students' collaboration skills and conceptual understanding in mathematics, particularly on 2D shapes, requires an innovative learning approach. This study aims to determine the effectiveness of Project-Based Learning (PjBL) based on Papuan local wisdom in improving collaboration skills and understanding of 2D shapes among fifth-grade students of MI Al-Ma'arif Sorong City. This research employed a quantitative approach using a quasi-experimental design with a Nonrandomized Control-Group Pretest–Posttest design. The subjects consisted of an experimental class and a control class. Data were collected through written tests, observation sheets, and documentation. The data were analyzed using N-Gain calculation, Mann–Whitney U test, and Independent Sample t-Test to determine significant differences between the two groups. The results showed that the implementation of PjBL based on Papuan local wisdom significantly improved students' collaboration skills and conceptual understanding. The experimental class achieved a medium category improvement, while the control class remained in the low category. These findings indicate that integrating Papuan local wisdom into the PjBL model is effective in enhancing students' social skills and deeper mathematical concept mastery.

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1. INTRODUCTION

The ability to collaborate and understand the concept of 2D shapes is two important aspects in learning mathematics at the elementary school level [1]. The ability to collaborate not only helps students in completing group tasks, but also fosters social skills [2], communication skills [3], and cooperation that are essential for academic development and daily life [4]. Meanwhile, understanding the concept of 2D shapes is an important foundation for mastering more complex mathematical material at the next level [5].

In Indonesia, especially in the Southwest Papua region, education faces unique challenges. Accessibility of education, equitable distribution of teacher quality, and limited facilities are issues that still need serious attention [6]. This condition has an impact on the effectiveness of the teaching and learning process, including in mathematics learning, which often still uses lecture methods and simple media [7]. Based on classroom observations conducted by the researcher in the 5th grade of MI Al-Ma'arif Sorong City, student interactions in groups were often limited to simple task sharing. Meaningful collaboration and deep exchange of ideas were not fully developed. In addition, students' understanding of the concept of 2D shapes is still surface and less connected to the real context around them. These conditions indicate that students' collaboration skills and conceptual understanding of 2D shapes have not developed optimally. There is a gap between the expected 21st-century learning competencies and the actual classroom practices, particularly in mathematics learning in Southwest Papua. Therefore, an innovative and contextual learning strategy is urgently needed to address this problem [8].

To address these challenges, this study proposes the implementation of Project Based Learning (PjBL) integrated with Papuan local wisdom as an innovative and contextual learning strategy [9]. By combining real-life cultural elements with project-based activities, students are expected to actively collaborate, construct their own understanding of 2D shapes, and connect mathematical concepts with their daily experiences [10]. This approach is designed not only to improve academic achievement but also to strengthen social interaction and cultural awareness among students [11].

Along with the development of 21st-century education, collaboration has become an essential skill that must be nurtured from an early age [12], [13]. The Project-Based Learning (PjBL) model has been proven to effectively foster active student engagement, enhance problem-solving abilities, and improve collaboration and conceptual understanding [14], [15]. PjBL enables learners to acquire knowledge through hands-on experiences, relate it to real-life contexts, and collaborate in completing projects that demand creativity and effective communication [16]. Integrating PjBL with local contexts allows students to learn from authentic experiences, thereby facilitating the transfer of knowledge and skills more effectively [17], [18].

Collaboration is one of the essential 21st-century skills for elementary students, as it fosters social interaction, communication, and teamwork necessary for academic and daily life [1], [2], [3]. According to Vygotsky (1978), learning occurs through social interaction and shared problem-solving, which emphasizes the importance of collaborative learning in classrooms. Therefore, developing collaboration skills early in elementary education is crucial to prepare students for more complex tasks and real-world problem-solving. Alongside collaboration, understanding core mathematical concepts such as 2D shapes is critical because it allows students to apply their collaborative problem-solving skills in meaningful learning contexts effectively. Understanding mathematical concepts, particularly 2D shapes, is fundamental for mastering more complex mathematical topics. According to Bruner (1960), students construct knowledge actively by connecting new concepts to prior knowledge, highlighting the need for hands-on and contextual learning. In this context, 2D shapes provide a foundation for spatial reasoning and problem-solving, which are key components of mathematics learning in elementary schools [4], [5]. Given the importance of both conceptual understanding and collaboration in learning 2D shapes, Project-Based Learning (PjBL) provides a suitable framework by enabling students to apply their knowledge through real-life projects that promote teamwork, creativity, and critical thinking.

PjBL emphasizes active learning through real projects, collaboration between students, and the development of creativity and critical thinking skills [19], [20]. In Indonesia, research shows that the implementation of PjBL in primary schools improves students' social skills, collaboration, and understanding of mathematical concepts [21], [22]. This approach allows learners to apply the concepts learned to real situations, so that learning becomes more contextual and meaningful. Project-Based Learning (PjBL) has been proven effective in engaging students in active learning, enhancing problem-solving abilities, and improving collaboration and conceptual understanding [8], [9]. PjBL enables learners to acquire knowledge through hands-on experiences, relate it to real-life contexts, and collaborate in completing projects that demand creativity and effective communication [10].

Integrating PjBL with local contexts further facilitates the transfer of knowledge and skills, making learning more meaningful and applicable [11], [12]. Integrating local wisdom into learning connects academic content with students' cultural context, making learning more relevant and meaningful. Local wisdom refers to the knowledge, values, and practices developed through interaction with natural and cultural environments [23]. Studies show that PjBL combined with local wisdom increases student engagement, collaboration, motivation, and critical thinking [24], [25]. In the Papuan context, cultural elements such as traditional headbands, Honai houses, and Tifa instruments provide authentic and creative media to strengthen students' understanding of 2D shapes while preserving their cultural identity.

Various studies in Indonesia show that the implementation of Project-Based Learning (PjBL) integrated with local wisdom is able to increase student involvement and make learning more meaningful because it is close to students' daily lives [23]. The integration of Papuan local wisdom in PjBL is a strategic step to make learning more contextual. Local wisdom refers to knowledge, values, and practices that develop in society through interaction with the natural environment and culture [24]. The rich Papuan culture, such as the shape of the Honai traditional house, the Thousand Feet House, the Kariwari House, and the traditional Tifa musical instrument, keeps patterns and shapes that are relevant to the concept of 2D shapes. By integrating these cultural elements, learners can understand mathematical concepts in a more real, creative, and meaningful way, while strengthening their cultural identity [25], [26].

In this study, the integration of Papuan local wisdom is realized through a traditional headband-making project. Each group of students was given a rectangular and triangular headband of varying sizes, and then calculated the circumference and area as an application of the concept of 2D shapes. After the calculation, students made and decorated the headband using keangan shells, imitating the design of traditional Papuan headbands. This activity not only emphasizes the practical application of mathematics but also encourages creativity, collaboration, and appreciation of local culture.

This approach utilizes local knowledge, values, and practices as learning mediums, so that learners not only understand mathematical concepts, but also appreciate their own culture [27], [28]. Previous studies in other areas have shown that integrating local wisdom into PjBL increases students' learning motivation, active engagement, and collaboration and critical thinking skills [29], [30]. Thus, the implementation of PjBL based on Papuan local wisdom is expected to bridge the understanding of academic concepts with real cultural experiences for students.

Several previous studies have shown the effectiveness of PjBL in increasing student engagement and collaboration [31], [32]. However, most of the studies have not emphasized the integration of Papuan local wisdom, so there is no strong empirical evidence on the application of local culture-based PjBL to improve collaboration and understanding of 2D shapes in elementary schools in the Southwest Papua region. Research related to local wisdom and PjBL is mostly carried out in areas with different cultural characteristics, so that the local context in Papua is still a research gap that needs to be filled.

In the context of the Merdeka curriculum, the government encourages more active, contextual, and student-centered learning [33], [34]. Teachers act as facilitators who motivate students to learn independently, develop collaborative skills, and understand concepts in depth [35], [36]. The implementation of PjBL combined with local Papuan wisdom is expected to meet these demands, as well as provide a meaningful and enjoyable learning experience for students.

Despite these promising approaches, there is still limited research that specifically investigates the integration of Papuan local wisdom in Project-Based Learning for teaching 2D shapes in elementary schools in Southwest Papua. Several previous studies have explored the implementation of Project Based Learning (PjBL) integrated with local wisdom in various regions, showing improvements in students' collaboration, motivation, and understanding of concepts [37], [38], [39]. However, few studies have specifically focused on integrating Papuan local wisdom in learning 2D shapes for elementary school students in Southwest Papua. This study addresses this gap by examining how culturally contextualized PjBL can enhance both collaboration skills and conceptual understanding of 2D shapes, while simultaneously fostering appreciation for local culture.

Based on the identified research gap, this study seeks to examine the implementation of Project Based Learning (PjBL) integrated with Papuan local wisdom in mathematics learning on 2D shapes for fifth-grade students of MI Al-Ma'arif Sorong City. This research not only aims to address the limited empirical evidence regarding culturally contextualized PjBL in Southwest Papua but also to contribute theoretically and practically to elementary mathematics education. Specifically, this study aims to: (1) analyze the differences in students' collaboration skills before and after the implementation of PjBL based on Papuan local wisdom; (2) analyze the differences in students' conceptual understanding of 2D shapes; and (3) determine the effectiveness of the proposed model in improving both abilities. The findings of this study are expected to provide empirical evidence regarding the effectiveness of integrating local culture into PjBL, as well as offer practical guidance for teachers in designing meaningful, contextual, and culturally responsive mathematics learning strategies in Southwest Papua.

2. METHOD

This study uses a quantitative approach because it focuses on measuring differences in the treatment of two objectively and numerically bound variables. The quantitative approach allows for the collection of data in the form of figures and statistical analysis to test the hypotheses that have been formulated [40]. The type of research applied was quasi-experimental with a Nonrandomized Control-Group Pretest–Posttest design, or known as a non-equivalent control group design. This design was chosen because the class that was the subject of the study was not randomly selected, but still allowed for comparisons between the experimental group and the control group that had relatively equivalent initial conditions [41]. In this study, class 5A was designated as an experimental group that received learning using the Project-Based Learning (PjBL) model based on Papuan local wisdom, while class 5C was a control group that received learning focused on teacher instruction without integration of PjBL or local wisdom [42].

The population of this study is all 5th-grade students of MI Al-Ma'arif Sorong City in the odd semester of the 2025/2026 school year, consisting of 25 students in class 5A and 24 students in class 5C. The sample was determined through purposive sampling techniques, which are selected based on criteria relevant to the research objectives, such as the relationship of 2D shape materials with the 5th-grade curriculum, teacher readiness, a balanced number of students, and classroom location that allows effective observation [43].

The data collection techniques in this study include written tests and observations. Written tests in the form of pretest and posttest were used to measure students' understanding of the concept of 2D shapes, with multiple-choice questions and descriptions adapted to the local context, for example, associating the material of 2D shapes with the Honai traditional house and Tifa musical instruments. Observations were carried out to assess students' ability to collaborate during the implementation of projects based on local wisdom using non-participatory observation rubrics.

The research instrument consists of test instruments and collaborative observation instruments. The concept comprehension test contains 20 questions developed based on the indicators of understanding the concept of 2D shapes according to Hudoyo (2003), including definitions, characteristics, explanation of concepts in their own words, examples, and non-examples, association with real objects, and solving related problems. The collaborative observation instrument used a Likert scale (1-5) with six indicators, such as the ability to convey ideas, listen to group members, carry out tasks, actively discuss, help resolve conflicts, and contribute to group tasks (Trilling & Fadel, 2009). Meanwhile, the documentation instrument records and archives visual and administrative data during the learning process.

The validity of the instrument was tested through content validity by two lecturers who are experts in mathematics learning and basic education, as well as a construct validity test for collaboration instruments [44], [45]. The reliability test was carried out using KR-20 for multiple-choice questions, Alpha Cronbach for description questions, and observation instruments according to Arikunto (2016). Data analysis was carried out with prerequisite tests in the form of normality tests and homogeneity tests. The normality test uses Shapiro-Wilk, while the homogeneity test uses Levene's test. Data that met parametric assumptions were analyzed using the Independent Sample t-Test to test for significant differences between the experimental and control classes. In contrast, N-Gain was used to assess the effectiveness of improved conceptual understanding and collaborative ability according to Hake (1999). Data that did not meet parametric assumptions were analyzed using the non-parametric Mann-Whitney U Test as an alternative to comparing the two groups [46], [47].

3. RESULTS AND DISCUSSION

3.1. Results

Based on the results of the research, the ability to collaborate and understand the concepts of students in classes 5A and 5C changed after the implementation of the Project-Based Learning (PjBL) model based on local Papuan wisdom. The ability to collaborate is obtained through observation, while conceptual understanding is obtained through pretest and post-test tests. Class 5A students receive learning using PjBL based on local Papuan wisdom, while class 5C follows learning as usual without the application of PjBL.

The N-Gain data on collaboration ability was analyzed using the Mann–Whitney U test because it did not meet the assumption of normality, while the N-Gain data on concept understanding was analyzed using the t-test because the data were normally distributed. This analysis aims to determine the difference in the level of improvement in collaboration skills and concept understanding between classes as the basis for assessing the effectiveness of PjBL based on Papuan local wisdom.

Table 1. Description of N-Gain Collaboration Skills and Understanding of Concepts of Students

Groups	**N**	**Red**	**SD**	**Categories**
Collaboration Capabilities				
5A	25	0,44	0,25	Medium
5C	24	-0,08	1,11	Low
Concept Understanding				
5A	25	0,54	0,27	Medium
5C	24	0,07	0,29	Low

Description: N = number of students; Red = average N-Gain; SD = standard deviation.

Category: N-Gain classification based on Hake (1999): ≥0.70 = High; 0.30–0.69 = Medium; <0.30 = Low.

Based on Table 1, the average N-Gain value of collaboration ability of class 5A students was 0.44 in the medium category, while in class 5C, it was -0.08 in the low category. Meanwhile, the average N-Gain value of concept understanding of class 5A students was 0.54 in the medium category, while in class 5C, it was 0.07 in the low category. To complete the description of N-Gain in Table 1, Figures 1 and 2 present the average final score of students' collaboration ability and concept understanding in grades 5A and 5C. This graph is presented as a visualization of the final learning results, so that it makes it easier for readers to see the difference in scores between the experimental and control classes after the implementation of PjBL based on local Papuan wisdom.

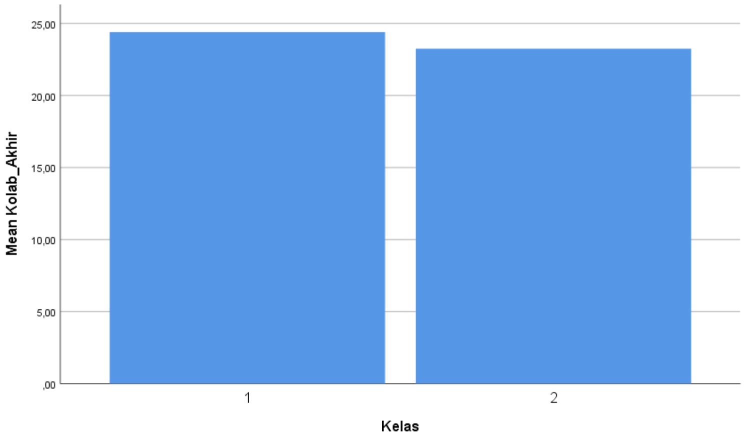

Figure 1. The average final collaboration ability of students in grades 5A and 5C.

Based on Figure 1, it can be seen that the average final score of the collaboration ability of class 5A students is higher than that of class 5C.

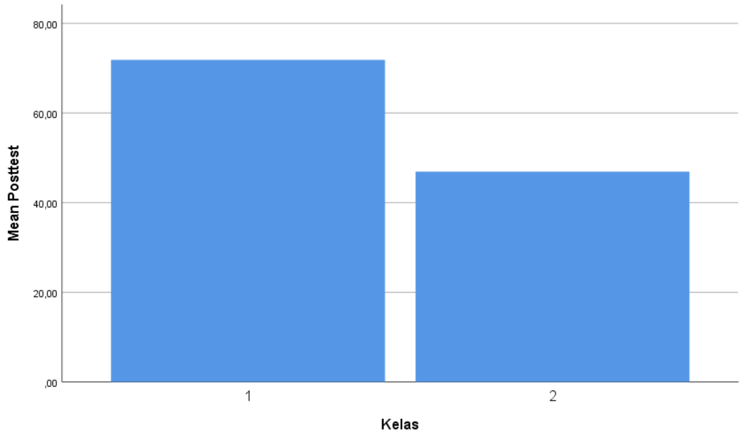

Figure 2. The average final understanding of concepts for students in grades 5A and 5C.

Based on Figure 2, it can be seen that the average final score of understanding concepts of students in class 5A is higher than in class 5C.

3.1.1 Students' Collaborative Abilities

To determine the statistical test technique used, a prerequisite test was first carried out in the form of a normality test and a homogeneity test on the N-Gain data on the ability to collaborate.

Table 2. N-Gain Normality Test of Collaboration Ability

Tests of Normality				
		Shapiro-Wilk		
	Classes	Statistic	df	Sig.
NGain_KO	5A	,939	25	,141
	5C	,569	24	,000

 https://doi.org/10.58421/gehu.v5i1.1167

Based on the results of the normality test on the N-Gain data on the ability to collaborate, a significance value (Sig.) for class 5A was obtained of 0.141 (> 0.05), which showed that the N-Gain data of class 5A was distributed normally. However, the significance value for class 5C is 0.000 (< 0.05), so the N-Gain data for class 5C is not normally distributed. Because one of the groups did not meet the assumption of normality, the analysis of differences in the improvement of collaboration ability between classes could not use the parametric test (Independent Sample t-Test), so the Mann-Whitney U non-parametric test was used.

Table 3. N-Gain Homogeneity Test Collaboration Ability

Test of Homogeneity of Variances					
		Living Statistic	df1	df2	Sig.
NGain_KO	Based on Mean	6,943	1	47	,011
	Based on Median	2,605	1	47	,113
	Based on Median and with adjusted df	2,605	1	24,184	,119
	Based on trimmed mean	4,005	1	47	,051

Based on Table 3, the results of the homogeneity test (Levene's Test) on the N-Gain data of the collaboration ability of students in grades 5A and 5C showed a Sig. value of 0.11 (> 0.05). This shows that the data variance of the two classes is homogeneous, so that both groups have relatively equal data diversity. Although the data variance was homogeneous, the results of the normality test showed that one of the groups was not normally distributed, so the parametric test could not be used, and the analysis was continued using the non-parametric Mann-Whitney U test.

Table 4. Mann-Whitney U Collaboration Test Results

Classes	N	Mean Rank	U	Z	Sig. (2-tailed)
5A	25	30,14			
5C	24	19,65			
			171,5	-2,572	0,010

Description:
N = number of students; Mean Rank = average Rank; U = Mann–Whitney statistical value; Z = the default statistical value; Sig. = significance value.

Based on Table 4, the Asymp value is obtained. Sig. (2-tailed) was 0.010 < 0.05, so it can be concluded that there is a difference in students' ability to collaborate between classes 5A and 5C after the implementation of PjBL based on local Papuan wisdom.

3.1.2 Understanding Student Concepts

After analyzing the ability to collaborate, the next analysis was focused on understanding the concept of 2D shapes for students to see the impact of PjBL based on local Papuan wisdom on cognitive aspects. This step is important to assess whether increased collaboration also impacts more in-depth mastery of math material.

Table 5. N-Gain Normality Test Understanding Concept

Tests of Normality					
			Shapiro-Wilk		
	Classes	Statistic	Statistic	df	Sig.
Ngain_PK	5A	,120	,966	25	,556
	5C	,120	,925	24	,074

Based on Table 5, the results of the Shapiro–Wilk normality test on the N-Gain data of concept understanding showed a significance value of 0.556 in class 5A and 0.074 in class 5C. Because the two significance values are greater than 0.05, the N-Gain data on concept understanding in both classes is declared to be normally distributed.

Table 6. N-Gain Homogeneity Test Collaboration Ability

Test of Homogeneity of Variances					
		Living Statistic	df1	df2	Sig.
Ngain_PK	Based on Mean	,082	1	47	,776
	Based on Median	,106	1	47	,746
	Based on Median and with adjusted df	,106	1	43,698	,746
	Based on trimmed mean	,101	1	47	,752

Based on Table 6, the results of the homogeneity test (Levene's Test) on the N-Gain data on the understanding of the concept of 2D shapes for students in grades 5A and 5C showed a Sig. value of 0.776 (> 0.05). This shows that the data variance of the two classes is homogeneous, so that both groups have relatively equal data diversity. In addition, the results of the normality test showed that the data in both classes were normally distributed, so that the analysis of the difference in N-Gain concept understanding could be continued using the parametric test of the Independent Samples t-test.

Table 7. Results of N-Gain Students' Concept Understanding

Classes	N	Red	SD	Sig. (2-tailed)
5A	25	0,54	0,27	0,000
5C	24	0,07	0,29	

Description: N = number of students; Red = average N-Gain; SD = standard deviation; Sig. (2-tailed) = from an independent t-test table, indicating whether the difference is significant

Based on Table 7, the independent t-test showed a Sig. (2-tailed) value of 0.000 < 0.05, so it can be concluded that there is a difference in students' understanding of the concept of 2D shapes between classes 5A and 5C after the application of PjBL based on local Papuan wisdom.

3.2. Discussion

Based on the results of the study, there was a significant difference in the improvement of collaboration ability between the experimental class (5A) that applied PjBL based on Papuan local wisdom and the control class (5C) that did not. The N-Gain level of collaboration ability in class 5A, which is included in the medium category, indicates that most students can work together more effectively. In contrast, the low category in class 5C indicates that without PjBL, the increase in collaboration tends to be minimal. This emphasizes that the implementation of PjBL explicitly encourages students to collaborate in each stage of learning, in contrast to control classes where interaction between students is not systematically structured.

The low increase in collaboration ability in the control class is likely due to the learning methods used by teachers on a daily basis that have not been designed to facilitate students' cooperation in completing a project. On the other hand, PjBL, based on local Papuan wisdom, requires students to actively cooperate, communicate, and be responsible in groups. These findings are in line with previous research [48], [49], which showed that without a project-based learning model, learners' collaborative abilities do not develop optimally.

In addition to the ability to collaborate, the implementation of PjBL based on Papuan local wisdom also has a positive influence on students' understanding of concepts. The experimental class showed a more significant improvement in conceptual understanding than the control class. These results show that project-based learning not only encourages social cooperation but also improves mastery of the material in greater depth. This is supported by previous research [50], [51], which states that the PjBL model is effective in improving concept understanding because learning is active, contextual, and motivates learners to explore concepts in depth.

The integration of local wisdom in learning also strengthens students' social interactions, making learning activities more contextual and meaningful [52]. Thus, PjBL, based on local Papuan wisdom, is able to increase social interaction, group responsibility, and understanding of concepts in real terms, in contrast to the control class that does not receive this intervention. These findings confirm that project-based learning strategies can be recommended to be applied more widely to improve the quality of learning and overall learning outcomes of students.

4. CONCLUSION

This study affirms the pedagogical significance of culturally responsive Project-Based Learning (PjBL) in primary mathematics education by demonstrating the value of integrating Papuan local wisdom into instructional design. Contextualized project-based experiences appear to foster meaningful engagement and socially grounded conceptual construction, highlighting the relevance of culturally situated learning frameworks. The study contributes theoretically to the discourse on contextual and culturally relevant pedagogy while offering practical direction for the structured implementation of locally grounded projects in classroom settings. However, its scope was confined to a single institutional context, limited subject matter, and a specific research design, which may constrain generalizability. Future research should investigate broader applications across disciplines, grade levels, and diverse educational environments to advance inclusive and culturally meaningful instructional practices further. Practically, this study offers guidance for teachers in structuring culturally grounded projects that promote active participation and collaborative engagement in mathematics classrooms.

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