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Peer tutoring in pbl with ethnomathematics approach to improve students' comprehension ability: a gender perspective

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Abstract

Mathematical understanding is essential for supporting students in solving problems, thinking logically, and developing self-confidence. However, many students at Madrasah Aliyah continue to experience difficulties in understanding mathematical concepts. These difficulties arise not only from low learning interest, the dominance of rote memorization, and the abstract nature of mathematics, but also from the lack of contextual relevance that connects mathematical ideas to students' cultural experiences. To address these issues, a peer tutoring strategy within ethnomathematics-based problem-based learning (PBL) was implemented. This approach allows students to collaborate with peers while engaging with culturally relevant contexts, making learning more meaningful. This study aims to examine the implementation of the strategy and evaluate its effect on students' mathematical understanding in terms of gender. A mixed-methods approach with an embedded design was employed, in which quantitative data served as the primary component for analyzing treatment effects, while qualitative data from observations and interviews were used to support and explain gender-related differences in the quantitative findings. The research involved 32 students at a Madrasah Aliyah in Bandung. Data were collected through questionnaires, tests, observations, interviews, and documentation; quantitative data were analyzed using two-way ANOVA and correlation tests, and qualitative data through triangulation. The two-way ANOVA results showed a significant main effect of the peer tutoring strategy in ethnomathematics-based PBL on mathematical understanding, as well as a significant interaction between learning strategy and gender, with female students outperforming male students. Improvements in self-confidence and cultural awareness were qualitatively observed rather than measured formally. These findings indicate that ethnomathematics-based PBL with peer tutoring offers a contextual and collaborative approach that effectively enhances students' mathematical understanding.

Keywords: collaborative learning, conceptual understanding, gender, local culture, peer tutoring

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INTRODUCTION

Mathematics learning in Madrasah Aliyah still faces various challenges, particularly in terms of students' low conceptual understanding and learning motivation (Yestina & Ratnaningsih, 2023). This issue is reflected in the results of the XI grade mathematics formative test in the academic year 2023–2024 as well as Indonesia's TIMSS scores, which remain below the international average (Hadi & Novaliyosi, 2019). Many students encounter difficulties in connecting mathematical content with real-life situations (Wiryana & Alim, 2023). Moreover, the perception that mathematics is a difficult, abstract, and irrelevant subject to daily life contributes to students' low motivation in learning mathematics (Yestina &

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Ratnaningsih, 2023; Wiryana & Alim, 2023; Supianti et al., 2020). The lack of variation in instructional strategies and the limited integration of mathematics with real-life or local cultural contexts further hinder students' ability to comprehend the taught concepts (Sulistyawati, 2018). In fact, mathematical understanding does not merely involve mastering content, but also the ability to comprehend, interpret, and apply knowledge across different contexts (Mulyono & Hapizah, 2018; Rambe et al., 2024; Damayanti, 2022; Supianti et al., 2019). Such understanding is closely related to students' ability to communicate mathematical ideas, making the learning process more meaningful and contextual (Damayanti, 2022; Supianti et al., 2020; Yaniawati et al., 2021; Ripa et al., 2021).

Conceptual understanding in mathematics is an essential aspect that students must possess in the learning process (Chandra, Amelia, & Hasibuan, 2021). Such understanding enables students to master the material more deeply, connect various concepts, and apply them in different contexts, including in daily life (Tauhid & Safari, 2024). Therefore, the use of learning strategies that are contextual, collaborative, and relevant to students' real-life experiences is highly important.

In an effort to improve students' conceptual understanding, careful consideration of instructional decisions implemented in the classroom is necessary (Mubarika, 2020). One potential strategy to enhance students' mathematical understanding is Peer Tutoring, a learning method in which students assist and teach one another (Yoviyanti, Wahyudi, & Suhendar, 2023). This strategy not only strengthens content mastery but also fosters students' social skills, collaboration, and self-confidence (Zubaidah, 2021). Previous studies have shown that Peer Tutoring effectively improves students' learning motivation (Hastari, 2019; Elfidra et al., 2024) as well as conceptual understanding (Ripa et al., 2021; Malik & Riafadillah, 2022; Novianti et al., 2022). Learning assistance provided by peers helps reduce awkwardness, makes the explanation easier to understand, and eliminates feelings of reluctance, inferiority, or shyness (Winarso, Santosa, & Sahria, 2024).

Another strategy is Problem-Based Learning (PBL), an approach that emphasizes solving real-world problems in a collaborative and student-centered manner, thereby promoting critical thinking and meaningful learning (Anugrah, 2023; Yaniawati et al., 2021). The implementation of PBL in mathematics learning has also been shown to develop students' collaboration skills (Irnadianis et al., 2024), enhance learning motivation (Diaz et al., 2023; Nurdiyanah, 2021), and improve conceptual understanding (Mardani et al., 2021). Other studies have compared Project-Based Learning (PJBL) and PBL, both of which were found to be effective in improving students' understanding and motivation (Yaniawati et al., 2021). Specifically, the integration of Peer Tutoring within PBL has been proven to support the enhancement of students' understanding and motivation (Zubaidah, 2021). Furthermore, the use of PBL can strengthen students' mathematical understanding and communication by considering gender differences (Damayanti, 2022).

Ethnomathematics is a field that bridges mathematics and culture (Sartika, Saputra, & Herizal, 2024). To enrich the learning context, ethnomathematics is integrated as an approach that connects school mathematics with local culture, making the learning process more relevant and closer to students' daily lives (Safitri & Siregar, 2023). Within the local cultural context, the ethnomathematics approach has also been proven to improve students' understanding and learning motivation (Putra et al., 2022). Moreover, the development of ethnomathematics-based learning materials has shown positive impacts on students' achievement and motivation (Rahmawati, 2017).

On the other hand, it is also important to consider gender factors, since differences in social roles and characteristics between male and female students may influence their responses to the applied learning strategies (Mualimah & Yusuf, 2022). Gender differences naturally lead to variations in

physiology, which in turn affect psychological aspects of learning (Yudiawati et al., 2021). Therefore, the integration of Peer Tutoring, PBL, and ethnomathematics, while also taking gender into account, represents an innovative approach that has the potential to enhance students' understanding and learning motivation in a holistic and contextual manner, particularly in the context of Madrasah Aliyah.

However, despite a wide range of studies on Peer Tutoring, PBL, ethnomathematics, and gender differences, most previous research has examined these variables only in pairs, such as focusing on Peer Tutoring combined with PBL, or ethnomathematics in relation to gender. Very few studies have simultaneously integrated Peer Tutoring, PBL, and ethnomathematics within a single instructional model while also analyzing the outcomes through a gender lens. This gap highlights the need for a more comprehensive and multidimensional investigation. Addressing this gap, the present study introduces a more holistic learning approach that merges these three frameworks to optimize students' mathematical understanding in Madrasah Aliyah.

Based on previous studies, the main distinction of this research lies in its approach, which combines Peer Tutoring and Problem-Based Learning (PBL) simultaneously, while also incorporating ethnomathematics and gender aspects as the focus of investigation. This integrated approach has rarely been explored, yet it holds significant potential to enhance students' learning comprehension in a holistic and contextual manner, particularly in Madrasah Aliyah (MA). The novelty of this study is the development of an ethnomathematics-based PBL model integrated with Peer Tutoring. This combination is expected to improve students' conceptual understanding. Therefore, the objectives of this research are (1) to analyze students' mathematical understanding using Peer Tutoring in PBL compared to conventional methods in terms of gender, and (2) to examine the factors influencing the successful implementation of Peer Tutoring within ethnomathematics-based PBL.

METHODS

This study employed a Mixed Method with an Embedded Design, in which the quantitative approach served as the primary design and the qualitative approach supported the analysis (Yaniawati & Indrawan, 2024). This approach was chosen to measure the improvement of students' mathematical understanding through the implementation of Peer Tutoring in ethnomathematics-based Problem-Based Learning (PBL), while also exploring in depth the supporting factors for its effectiveness (Damayanti, 2022; Safitri & Siregar, 2023; Ripa et al., 2021). The research procedure consisted of three stages: preparation, implementation, and field application. Preparation Stage: This included problem identification through literature review and preliminary observation, development of the conceptual framework and research objectives, design of both quantitative and qualitative methods, as well as preparation of the work plan, scheduling, and initial coordination with the school.Implementation Stage: This stage involved the development of research instruments (mathematical understanding test, motivation questionnaire, interview guidelines, and observation sheets) and learning tools (lesson plans and teaching materials based on PBL, ethnomathematics, and peer tutoring in the topic of Derivatives Applications of Algebraic Functions). The instruments and learning tools were validated by experts and tested on a limited scale before being revised. Field Application Stage: The validated instruments and learning tools were implemented in one private Madrasah Aliyah in Bandung City to measure their effectiveness in the learning process.

The study was conducted in one Madrasah Aliyah in Bandung City involving 32 grade XI students, consisting of 15 female students and 17 male students. Class XI-A (16 students) was assigned as the

control group and received conventional learning, while Class XI-B (16 students) served as the experimental group and received instruction through Peer Tutoring integrated into ethnomathematics-based Problem-Based Learning (PBL). The implementation was carried out over six learning sessions from April 16 to May 22, 2025. This group assignment enabled a clear comparison of students' mathematical understanding based on the applied instructional strategies. During the learning process, quantitative data were collected through pre-test and post-test assessments of students' mathematical understanding. The mathematical understanding test consisted of five open-ended items. The validity of the items was confirmed through expert judgment and empirical testing, with all items showing significance values below 0.05. The test demonstrated acceptable reliability with a Cronbach's Alpha of 0.649. Observation sheets and interview guidelines were also validated by experts to ensure content accuracy. These validated and reliable instruments ensured accurate and consistent measurement of students' mathematical understanding within the ethnomathematics-based PBL integrated with Peer Tutoring.

The next step was to conduct quantitative and qualitative data analyses separately yet complementarily. Before the main statistical tests, assumption testing was performed. Since the sample size was below 50, the Shapiro–Wilk test was used to assess data normality, while Levene's test was applied to examine the homogeneity of variances. The quantitative analysis aimed to measure differences in students' understanding scores between groups and to examine the influence of gender factors. A two-way ANOVA was employed to analyze students' mathematical understanding based on the learning model and gender.

Meanwhile, qualitative data obtained from interviews and observations were analyzed through coding procedures to identify key themes related to the effectiveness of the implemented learning strategy. Finally, the results of the quantitative and qualitative analyses were integrated within the embedded design framework through data triangulation, allowing for a more comprehensive and in-depth interpretation of the findings.

RESULTS AND DISCUSSION

Students' mathematical understanding showed improvement, as evidenced by the results of the pre-test and post-test, as well as the findings from the two-way ANOVA test. The class that received instruction using Peer Tutoring within ethnomathematics-based Problem-Based Learning (PBL) achieved better scores compared to the class taught using the conventional approach.

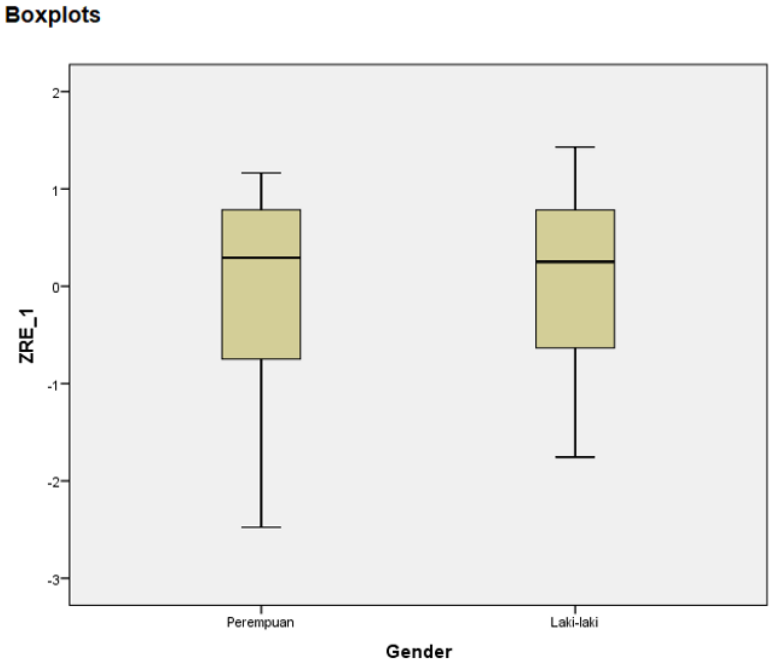
Table 1. Pre-test and Post-test Scores by Gender

Gender	Experimental				Control			
	Pretest		Postest		Pretest		Postest	
	$\underline{x}$	std	$\underline{x}$	std	$\underline{x}$	std	$\underline{x}$	std
Male	40,71	11,912	57,57	14,223	39,66	15,857	66,2	12,237
Female	48,00	12,35	84,22	10,616	60,5	14,419	80,16	13,060
Overall	44,8	12,330	72,56	18,096	48	19,218	72,13	13,966
Overall	44,8	12,330	72,56	18,096	48	19,218	72,13	13,966

Based on the descriptive statistics presented in Table 1, it can be seen that the mean scores of each class increased both before and after the treatment. The class taught using Peer Tutoring within PBL outperformed the conventional class, although the difference was not very large. Nevertheless, there

was a significant difference between the class taught with PBL and the conventional class (Kurniasih, Raharjo, & Yuwono, 2024). The average post-test score in the Peer Tutoring within PBL class was 72.56, with female students scoring an average of 84.22 and male students 57.57. In the class taught using a conventional approach, the average score was 72.00, with female students scoring an average of 80.16 and male students 66.20. Female students achieved higher scores compared to male students, both in the class taught with Peer Tutoring within PBL and in the conventional class. Overall, the mean pre-test and post-test scores increased in both groups, but the improvement was greater in the class that applied Peer Tutoring within ethnomathematics-based PBL. These results indicate that students' cognitive abilities can be categorized as good (Azzahra et al., 2023).

The following box plot presents the mean post-test scores of conceptual understanding for male and female student groups to further reinforce the findings related to gender differences.



In this study, the class that implemented the Peer Tutoring strategy in ethnomathematics-based Problem-Based Learning (PBL) demonstrated a higher improvement in mathematical understanding compared to the class taught using conventional methods. The Peer Tutoring strategy in ethnomathematics-based PBL proved to be more effective in actively engaging students in the learning process, fostering social interaction, and deepening the understanding of mathematical concepts within the context of local culture (ethnomathematics). This is in line with the findings of Kurniawan & Sulandra (2020), who stated that the Peer Tutoring strategy in PBL significantly enhances mathematics learning outcomes since students become more active and responsible for shared understanding. The interaction between tutors and tutees strengthens mathematical communication and conceptual comprehension. Furthermore, the integration of local culture in PBL makes the learning materials more contextual and meaningful for students. They become more interested, actively engaged in discussions, and better able to understand mathematical concepts through problems that are closely related to their daily lives. Fauziah and Utami (2020) also highlighted that integrating ethnomathematics into mathematics learning not only improves conceptual understanding but also strengthens students' cultural identity. This is consistent with the interview findings in this study. Student A stated, "I understood the material on derivatives of algebraic functions better because I did not feel awkward or embarrassed to ask questions

to my peers, even when I needed repeated explanations." Student B added, "In addition to learning about derivatives of algebraic functions, we also gained new knowledge about local cultural elements such as nasi tumpeng, asepan, and nyiru." These responses illustrate that the integration of Peer Tutoring and ethnomathematics-based PBL not only facilitated deeper conceptual understanding but also increased students' comfort and enriched their cultural awareness during the learning process.

Based on the normality test of the improvement in students' mathematical understanding, H_0 was accepted, indicating that the data were normally distributed. The homogeneity test of the improvement scores, both overall and across gender groups, showed significance values greater than 0.05; therefore, H_0 was accepted. This indicates that the improvement in mathematical understanding in both classes was homogeneous. Accordingly, the mean differences between the two classes were further analyzed using a two-way ANOVA.

Table 2. Two-Way ANOVA Test Results for Score Improvement in Mathematical Understanding Ability

Factor	Comprehension				
	Df	Mean square	F	Sig	Ho
Overall	1	61,815	0,392	0,537	Ho is accepted
Gender	1	2999,472	19,000	0,000	Ho is rejected
Overall*Gender	1	364,943	2,312	0,140	Hoisaccepted

a. R Squared = .436 (Adjusted R Squared = .376)

Table 2 shows that overall, the use of the Peer Tutoring strategy in ethnomathematics-based Problem-Based Learning (PBL) provided a significant improvement in students' mathematical understanding compared to the conventional method. This is indicated by the significance value (sig) being less than $\alpha = 0.05$, which demonstrates that the combined strategy is more effective in strengthening students' mathematical understanding in general. Furthermore, in terms of gender categories, the ANOVA results also revealed that the implementation of this strategy enhanced mathematical understanding for both male and female students compared to the conventional method. There was a significant difference in the improvement of scores between males and females, indicating that gender does influence students' responses to the learning strategy. The next step was to further explore the differences in responses based on gender by conducting a multiple comparisons (post hoc) test. This test aimed to identify in detail how the improvement in mathematical understanding differed between male and female students when the Peer Tutoring strategy in ethnomathematics-based PBL was applied. As shown in Table 2, the significance value of 0.140 (learning strategy by gender) indicated that there was no statistically significant interaction effect between the two variables. Therefore, the researcher proceeded with the Post Hoc test to clarify and strengthen the findings of this study.

Tabel 3. Post Hoc

(I) Post Hoc	(J) Post Hoc	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Peer Tutoring in Ethnomathematics-Based PBL for Female Students	Peer Tutoring in Ethnomathematics-Based PBL for Male Students	26.65*	6.332	.001	9.36	43.94
	Female Students in Conventional Method	4.06	6.622	.927	-14.02	22.14
	Male Students in Conventional Method	16.92*	5.773	.032	1.16	32.68
Peer Tutoring in Ethnomathematics-Based PBL for Male Students	Peer Tutoring in Ethnomathematics-Based PBL for Female Students	-26.65*	6.332	.001	-43.94	-9.36
	Female Students in Conventional Method	-22.60*	6.990	.016	-41.68	-3.51
	Male Students in Conventional Method	-9.73	6.192	.411	-26.63	7.18
Female Students in Conventional Method	Peer Tutoring in Ethnomathematics-Based PBL for Female Students	-4.06	6.622	.927	-22.14	14.02
	Peer Tutoring in Ethnomathematics-Based PBL for Male Students	22.60*	6.990	.016	3.51	41.68
	Male Students in Conventional Method	12.87	6.488	.218	-4.85	30.58
Male Students in Conventional Method	Peer Tutoring in Ethnomathematics-Based PBL for Female Students	-16.92*	5.773	.032	-32.68	-1.16
	Peer Tutoring in Ethnomathematics-Based PBL for Male Students	9.73	6.192	.411	-7.18	26.63
	Female Students in Conventional Method	-12.87	6.488	.218	-30.58	4.85

Based on observed means.
The error term is Mean Square (Error) = 157.864.
*. The mean difference is significant at the .05 level.

Based on the Post Hoc results presented in Table 3, several findings can be highlighted: The implementation of Peer Tutoring in ethnomathematics-based PBL had a greater effect on female students compared to male students under the same conditions, as well as compared to males in the conventional method. Male students in the Peer Tutoring ethnomathematics-based PBL group did not show a significant difference in mathematical understanding compared to male students in the conventional method. Female students in the conventional method did not differ significantly from females in the Peer Tutoring ethnomathematics-based PBL group. However, they still performed better than males in the Peer Tutoring ethnomathematics-based PBL group.

When examined from a gender perspective, it is evident that female students consistently scored higher than male students, both in classes that applied the Peer Tutoring strategy in ethnomathematics-based PBL and in those taught with conventional methods. Based on the data presented in Table 3, female students outperformed their male counterparts overall.

This finding is consistent with Hyde and Mertz (2009), who emphasized that gender differences in mathematical ability are not biological in nature but are strongly influenced by cultural and social factors. In countries with higher levels of gender equality, female students often achieve higher scores than males. Similarly, the TIMSS 2019 report (Mullis et al., 2020) also revealed that in several countries,

female students demonstrated better performance than males in mathematics and science, particularly at the primary and lower secondary levels.

The Peer Tutoring strategy in ethnomathematics-based PBL, which involves group work, discussions, peer tutor assignments, and contextual problem-solving based on local culture (e.g., nasi tumpeng), was proven to enhance students' mathematical understanding while fostering a more active and collaborative learning atmosphere (Anugrah, 2023). Overall, collaborative learning approaches create an inclusive and responsive learning environment, establishing a supportive learning community among students, which in turn increases engagement, motivation, and comprehension throughout the learning process. Furthermore, Peer Tutoring has been shown to improve students' learning motivation (Hastari, 2019). In this regard, teachers should carefully consider appropriate instructional strategies before deciding on the type of learning approach to be developed in students' thinking, while also paying attention to the effectiveness of teaching and learning in supporting conceptual understanding (Mulyono & Hapizah, 2018). Thus, the Peer Tutoring strategy in ethnomathematics-based PBL can be considered an appropriate approach to mathematics instruction, as it simultaneously enhances both students' motivation and their mathematical understanding.

Several factors contributed to the successful implementation of the Peer Tutoring strategy in ethnomathematics-based Problem-Based Learning (PBL). These include the classroom atmosphere and learning environment, the quality of communication among students, and students' learning motivation. From a gender perspective, female students demonstrated better mathematical understanding compared to male students. This can be attributed to the fact that female students tend to be more communicative, meticulous, and patient in solving problems, while some male students were more likely to rush through the tasks, showed less communicative behavior, and displayed lower enthusiasm in group work. Gallagher and De Lisi (1994) also reported that female students often outperform their male peers in mathematical tasks under certain conditions. Therefore, it is important for educators and teachers to pay attention to and foster the interest and learning motivation of all students in order to strengthen their understanding of mathematical concepts (Chandra, Amelia, & Hasibuan, 2021).

The results of student interviews during the learning process indicated that students felt happy and motivated when learning through the Peer Tutoring strategy in ethnomathematics-based PBL. The learning activities were perceived as enjoyable, students were not hesitant during discussions, and positive communication occurred among peers. In addition to learning mathematics, students also gained insights into local culture, in this case through nasi tumpeng, which contributed to an improvement in their mathematical understanding. Students who were more actively engaged in group interactions benefited from the role of peer tutors to better comprehend the material. Those with stronger understanding acted as tutors for peers who needed assistance. According to Lase and Subekti (2024), this approach significantly enhanced students' ability to solve contextual problems. Moreover, students' active participation during group discussions strengthened their mastery of mathematical concepts at a deeper level.

These findings are consistent with Sarwoedi et al. (2018), who reported that the implementation of ethnomathematics effectively improves students' mathematical understanding, particularly in interpreting symbols, applying mathematical ideas, and engaging in meaningful mathematical explorations. When students discuss within the context of their own culture, conceptual understanding develops not only cognitively but also contextually. Therefore, teachers are encouraged to design instructional strategies that are rooted in local contexts and relevant to students' lives (Hulwah & Suryani, 2025).

CONCLUSION

The implementation of a Peer Tutoring strategy within Ethnomathematics-based Problem-Based Learning (PBL) has been shown to significantly enhance the mathematical conceptual understanding of Madrasah Aliyah students compared to conventional methods. Notably, female students demonstrated superior achievement relative to their male counterparts, although mathematical representation skills regarding the determination of maximum function values still require further reinforcement. The success of this approach, which integrates local cultural contexts such as nasi tumpeng, is underpinned by an inclusive and interactive learning environment, rendering it a viable model for broader implementation to simultaneously improve academic outcomes and preserve local culture. Based on the challenges encountered during the research, the researcher provides the following suggestions: 1) Teachers should give a brief orientation on the steps of the Peer Tutoring strategy within Problem-Based Learning (PBL) based on ethnomathematics, including simple examples or simulations to help students quickly understand the learning flow. 2) Since the adaptation phase in the initial meetings requires considerable time, teachers are advised to establish clear discussion rules from the beginning and conduct a short role play illustrating the roles of tutor and tutee to help students adapt more easily. 3) For students who are less responsive to teacher instructions, learning activities should be made more engaging by incorporating contextual media, real-life problem situations, or short ice-breaking activities to maintain students' learning motivation.

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