

Effectiveness of Ethnomathematics-Integrated Realistic Mathematics Education on Mathematical Communication Skills

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ABSTRACT

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Mathematical communication skills are essential higher-order thinking competencies that enable students to express mathematical ideas, reasoning, and representations logically and coherently. However, students often experience difficulties in connecting formal mathematical concepts with meaningful real-life situations. To address this issue, this study integrates Ethnomathematics into Realistic Mathematics Education (RME) by systematically embedding local cultural contexts from Southeast Sulawesi into all phases of learning. The ethnomathematics contexts included woven fabric patterns, kasuami food, and traditional house architecture as starting points for mathematical exploration and discussion. Unlike previous studies that applied RME or ethnomathematics separately, this study combines both approaches to specifically enhance students' mathematical communication skills. This study aimed to analyze the effectiveness of Ethnomathematics-Integrated RME in improving students' mathematical communication skills. A quantitative quasi-experimental method with a one-group pretest-posttest design was conducted involving 32 junior high school students. Data were collected using a mathematical communication skills test based on four indicators: expressing mathematical ideas, using mathematical symbols and representations appropriately, explaining reasoning logically, and connecting mathematical concepts to contextual situations. The results showed that the mean score increased from 44.72 on the pretest to 73.88 on the posttest. A paired sample t-test indicated a significant improvement ($t = 17.66, p < 0.05$), demonstrating that Ethnomathematics-Integrated RME effectively improved students' mathematical communication skills. These findings suggest that integrating local cultural contexts into RME creates meaningful and culturally responsive mathematics learning while strengthening students' conceptual expression and participation. This study provides an empirically supported framework for enhancing mathematical communication through culturally integrated mathematics instruction at the junior high school level.



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A. INTRODUCTION

Mathematical communication skills are essential competencies in junior high school mathematics learning because they enable students to express ideas, explain procedures, use mathematical symbols, and interpret information logically and systematically. These skills support conceptual understanding, reasoning, and problem-solving processes (Asikin et al.,

2021; Junaila & Yerizon, 2021). Therefore, mathematics learning should emphasize not only final answers but also students' ability to communicate mathematical thinking meaningfully.

Reports from international assessments provide a current picture of Indonesian students' literacy and numeracy performance at the global level. Usman et al. (2024) stated that the results of the Programme for International Student Assessment (PISA) 2022 revealed that Indonesian students' mathematical literacy score was 366, far below the OECD average of approximately 472 points. About 82 percent of 15-year-old students performed below the minimum proficiency level (Level 2), indicating difficulties in applying mathematical concepts to real-life contexts. This score declined from the 2018 PISA result of 379, reflecting stagnation in students' numeracy performance over the past two decades. Indonesia also ranked around 70th among more than 80 participating countries, indicating that it still lags behind many countries in Southeast Asia and globally. Previous studies similarly reported that Indonesian students experience difficulties in mathematical literacy, reasoning, and contextual problem solving (Budayasa & Juniati, 2019; Islami & Priatna, 2021). Other studies also highlighted persistent weaknesses in students' numeracy performance and mathematical understanding at the secondary school level (Maryono et al., 2021; Minarti & Wahyudin, 2019; Muslim, 2020). These findings reflect major challenges for the national education system in improving students' fundamental mathematical competencies.

National assessment data also indicate low cognitive achievement among Indonesian students. The results of the 2025 Academic Competency Test (ACT) showed that the average mathematics score across educational levels was approximately 36.10 on a scale of 0–100. This average is far below the expected level of academic development, indicating that many students still experience difficulties in understanding and applying mathematical concepts logically and analytically. Similar findings have been reported in previous studies showing that Indonesian students often struggle with mathematical reasoning, conceptual understanding, and contextual problem solving (Mulbar et al., 2019; Rohmanawati et al., 2021; Susilawati, 2021). In addition, Suwarno et al. (2020) found that students' numeracy achievement remains relatively low, particularly in solving application-based mathematical tasks. These findings are consistent with the PISA results, which demonstrate that students' mathematical literacy and application skills remain limited.

Evidence from PISA and ACT suggests that students' mathematical communication skills remain at low to moderate levels. Students tend to have difficulty explaining the reasoning behind procedures, presenting solution steps systematically, and translating contextual problems into mathematical models. Observations in several schools indicate that students' responses often consist only of final answers without explanation. Errors in the use of symbols, limited visual representations, and difficulties in interpreting results are also frequently found (Maelasari & Wahyudin, 2017; Primadani et al., 2020). Similar studies also reported that students face challenges in expressing mathematical ideas clearly and using appropriate mathematical representations during problem solving (Wandari & Anggara, 2021; Zulkarnain et al., 2021).

These conditions indicate a gap between curriculum expectations and students' actual competencies. The problem is closely related to instructional practices that remain oriented toward procedures and memorization. Teachers often emphasize mechanical problem solving

without providing opportunities for students to express ideas, justify reasoning, and engage in mathematical discussion. Previous studies have shown that procedural learning environments tend to limit students' mathematical communication and conceptual understanding (Junaila & Yerizon, 2021; Zetriuslita & Uswatun, 2020). In addition, abstract learning that is disconnected from students' experiences makes mathematical concepts difficult to understand meaningfully. Limited contextual learning environments also reduce students' opportunities to connect mathematics with real-life situations and communicate mathematical thinking actively (Ningtias et al., 2020; Zulhelmi & Anwar, 2021).

One factor contributing to this problem is the dominance of procedural and teacher-centered instruction. Mathematics learning is still frequently focused on memorization and mechanical problem solving, with limited opportunities for students to discuss ideas, justify solutions, or connect mathematics with real-life experiences. As a result, students' participation in communicating mathematical thinking remains low.

Realistic mathematics education (RME) is considered a relevant approach to address this issue because it emphasizes meaningful contexts, modeling, discussion, and active student participation in constructing mathematical ideas (Fatra et al., 2025). RME encourages students to explain strategies, compare solutions, and communicate reasoning during the learning process. Previous studies have shown that RME can improve conceptual understanding and problem-solving abilities (Laurens et al., 2017; Listyaningrum et al., 2025). In addition, the integration of ethnomathematics can strengthen contextual learning by connecting mathematical concepts with students' cultural experiences and local practices. Familiar cultural contexts help students understand abstract concepts more concretely and encourage them to express mathematical ideas both verbally and in written form (Hamidah et al., 2023; Wulandari et al., 2023).

Although RME and ethnomathematics have been widely studied, most previous research has examined them separately. Studies on RME mainly focus on conceptual understanding and problem solving, while ethnomathematics research generally emphasizes motivation and learning outcomes (Hayati et al., 2026; Prahmana & D'Ambrosio, 2020). Research integrating ethnomathematics within the RME framework, particularly to improve mathematical communication skills at the junior high school level, remains limited. This indicates a clear research gap regarding how culturally contextualized RME learning can support students' ability to communicate mathematical ideas through explanations, representations, and arguments.

Therefore, this study integrates ethnomathematics into the RME approach to improve students' mathematical communication skills. The scientific contribution of this study lies in providing empirical evidence on the effectiveness of culturally responsive and contextual mathematics instruction in enhancing students' mathematical communication through discussion, multiple representations, and meaningful learning experiences. This study is also expected to contribute to the development of innovative mathematics instruction that integrates contextual learning, cultural relevance, and social interaction in junior high school classrooms.

B. METHODS

This study employed a quasi-experimental method to examine the effectiveness of the ethnomathematics-based RME approach in improving students' mathematical communication skills. The research was conducted from July to September 2024 at SMP Negeri 11 Kendari. The study applied a one-group pretest–posttest design, which enabled the researcher to measure changes in students' mathematical communication skills before and after the instructional intervention. This design was selected because it allows the investigation of instructional effectiveness within an authentic classroom setting where random assignment of participants was not feasible (Usman et al., 2021). In addition, the use of pretest and posttest measurements helped control baseline differences in students' initial abilities and provided empirical evidence of learning improvement after the treatment.

To minimize potential bias, several control efforts were implemented during the study. The same teacher conducted all instructional sessions using standardized lesson plans and learning materials developed by the researcher. The duration of instruction, learning objectives, and assessment procedures were kept consistent throughout the treatment process. Furthermore, the pretest and posttest instruments used equivalent indicators of mathematical communication skills to ensure measurement consistency. The research design is illustrated as shown in Figure 1.

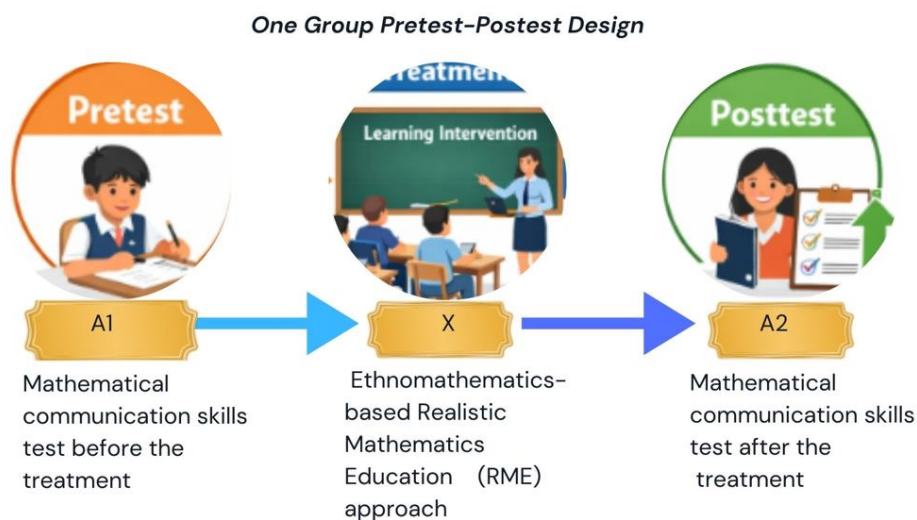


Figure 1. Design Research

Description: X is implementation of the ethnomathematics-based Realistic Mathematics Education approach; A1 is pre-test mathematical communication skills test before the treatment; and A2 is post-test mathematical communication skills test after the treatment. The population of this study consisted of ninth-grade students at SMP Negeri 11 Kendari. The sample was selected randomly from one class, consisting of 32 students. Data collection techniques included the development of learning materials, a mathematical communication skills test, and documentation.

Prior to data collection, the instrument was evaluated to ensure its validity and reliability. Content validity was established through expert reviews conducted by mathematics education experts and experienced mathematics teachers. Item validity was further tested using

Pearson's product-moment correlation analysis, showing that all four items met the validity criteria with significance values below 0.05. Reliability analysis using Cronbach's Alpha produced a coefficient of 0.965, indicating a very high level of internal consistency. Therefore, the instrument was considered appropriate for measuring students' mathematical communication skills. Data analysis was carried out using both descriptive and inferential statistics. To examine the effectiveness of the implemented learning approach, a paired sample t-test was applied to compare students' scores before and after the treatment.

C. RESULT AND DISCUSSION

1. Result

This study aimed to examine the effectiveness of Ethnomathematics-Integrated RME in improving students' mathematical communication skills. The data analyzed consisted of pretest and posttest scores of mathematical communication skills obtained from 32 students. Descriptively, the results of the pretest and posttest analysis of students' mathematical communication skills are presented in Table 1.

Table1: Descriptive Statistics of Pretest and Posttest Data for Mathematical Commucition Skills

No.	Category	Pretest	Posttest
1	Mean	44,72	73,875
2	Median	45	74
3	Mode	49	74
4	Standard Deviation	5,02	8,31
5	Variance	25,24	69,08
6	Maximum Score	54	90
7	Minimum Score	32	60

Based on Table 1, the results indicate an improvement in students' mathematical communication skills after the implementation of the instructional approach. The mean pretest score was 44.72 with a standard deviation of 5.02. The minimum pretest score was 32, while the maximum score was 54. These results indicate that students' initial mathematical communication skills were in the low category.

The posttest results show a substantial improvement. The mean posttest score increased to 73.88 with a standard deviation of 8.31. Based on the predetermined assessment criteria, the posttest mean falls into the high category. The minimum score obtained was 60 and the maximum score was 90. The wider score range and higher mean in the posttest indicate that most students experienced improvement in their mathematical communication skills after the learning intervention. The improvement is also reflected in the mean difference between the pretest and posttest scores, which reached 29.16 points. These findings suggest a considerable change in students' abilities following the implementation of Ethnomathematics-Integrated Realistic Mathematics Education. A comparison of the mean and standard deviation of pretest and posttest mathematical communication skills between groups is presented in the bar chart shown in Figure 2.

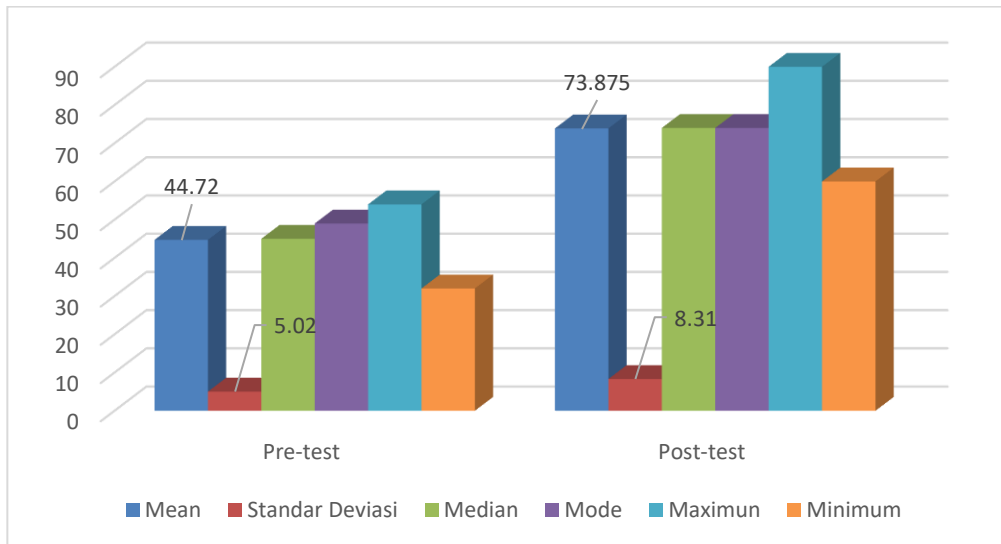


Figure 2. Pretest–Posttest Mean and Standard Deviation of Mathematical Communication

The improvement in students' mathematical communication skills after the implementation of the ethnomathematics-based RME approach was analyzed by comparing pretest and posttest scores. This analysis was conducted to identify whether the learning intervention produced a significant difference in students' performance before and after the treatment. A paired-sample t-test at the 0.05 significance level was employed to evaluate the statistical significance of the improvement. The results of the calculation for testing the improvement in mathematical literacy skills in Experimental Class 1 (the class that received instruction using the ethnomathematics-based Realistic Mathematics Education (RME) approach) are presented below. The statistical hypotheses tested are as follows:

$$\begin{aligned}
 H_0 : \mu_1 &= \mu_{post} - \mu_{pre} \leq 0, \text{ Vs} \\
 H_1 : \mu_1 &= \mu_{post} - \mu_{pre} > 0
 \end{aligned}
 \tag{1}$$

The null hypothesis (H_0) is rejected if the significance value is less than $\alpha = 0.05$; otherwise, H_0 is accepted. A summary of the analysis results is presented in Table 2.

Table 2. Test of Improvement in Mathematical Communication Skills

	Variable 1	Variable 2
Mean	73,875	44,72
Variance	69,08	25,24
Observations	32,00000	32,00000
Pearson Correlation	0,08565	
Hypothesized Mean Difference	0,00000	
df	31,00000	
t Stat	17,66555	
P(T<=t) one-tail	0,00000	
t Critical one-tail	1,69552	
P(T<=t) two-tail	0,00000	
t Critical two-tail	2,03951	

Based on the output of the mathematical communication improvement test using the paired-samples t-test shown in Table 2, the significance value was 0.000. Since this value is less than 0.05, the null hypothesis (H_0) is rejected. This indicates that instruction using the ethnomathematics-based Realistic Mathematics Education (RME) approach has a significant effect on improving students' mathematical communication skills.

2. Discussion

The improvement in mathematical communication skills indicates that students became more capable of expressing mathematical ideas in a written and systematic manner. This outcome is closely related to the characteristics of the RME approach, which emphasizes students' active involvement in constructing concepts through contextual problems. Learning begins with real-life situations that are familiar to students, enabling them to better understand problems and communicate their solution strategies.

The integration of ethnomathematics played an important role in creating meaningful learning contexts. The use of local cultural elements made the learning situations more familiar to students. Such conditions helped students understand problems and explain the relationships between contextual situations and mathematical concepts. Learning environments that are closely related to students' experiences also increased their confidence in expressing ideas.

The learning process, which involved group discussions and presentations, also contributed to the development of communication skills. Interaction among students provided opportunities to exchange ideas, clarify thinking, and correct misconceptions. Presenting group work encouraged students to communicate their ideas in a logical and systematic manner. These activities are consistent with constructivist theory, which emphasizes that knowledge is constructed through social interaction and learning experiences.

The findings are also consistent with the principles of RME, which emphasize horizontal and vertical mathematization. In the initial stage, students connect contextual problems with informal models. The subsequent stage guides students toward formal and symbolic representations (Ardiyani & Gunarhadi, 2018; Indiyarti Putri et al., 2025; Supiyati et al., 2019; Utami et al., 2019). This process provides students with opportunities to explain each step of their solutions, allowing mathematical communication skills to develop gradually.

The improvement in mathematical communication skills can also be explained through Vygotsky's social theory. Interaction in collaborative learning groups enables students to receive support from peers and teachers. This process helps students develop their thinking and communication abilities within their zone of proximal development. A collaborative learning environment encourages students to actively express ideas and respond to others' opinions.

The findings of this study support previous research indicating that the RME approach improves students' mathematical communication skills. Contextual and student-centered learning provides broader opportunities for students to develop various forms of mathematical representation. The integration of ethnomathematics further strengthens the effectiveness of the approach through culturally relevant learning contexts.

The significant difference between pretest and posttest scores suggests that conventional instruction previously implemented did not provide sufficient opportunities for students to develop mathematical communication skills. Procedural-oriented learning tends to make students focus only on final answers without explaining the solution process. Ethnomathematics-Integrated RME shifts learning toward a more active, reflective, and communicative process (Yilmaz, 2020). Improvements in communication skills were observed across several indicators. Students became more capable of presenting solution steps systematically, using mathematical symbols appropriately, and representing information in the form of tables or diagrams. Their ability to justify the strategies used also improved. These changes indicate that the instructional approach enhanced not only learning outcomes but also the quality of students' thinking processes.

The implementation also showed increased student participation during learning activities. Students were more active in discussions and more confident in expressing their opinions. Interactive and contextual classroom environments created more engaging learning conditions. Increased learning motivation also contributed to the development of mathematical communication skills. Nevertheless, some students still experienced difficulties in using formal mathematical language. This condition indicates that the development of mathematical communication requires sustained practice and continuous guidance (Minarti & Wahyudin, 2019). Teachers need to provide consistent feedback and opportunities for students to express ideas using various representations. The results of this study have important implications for mathematics teaching practices. Instruction that integrates cultural contexts and contextual learning approaches can serve as an alternative strategy to improve the quality of mathematics learning (Sumirattana et al., 2017). Teachers are encouraged to develop instructional materials that utilize local cultural resources and to facilitate discussion and presentation activities.

The findings also contribute to the development of culturally responsive mathematics education. The integration of ethnomathematics not only enhances conceptual understanding but also helps students recognize the relevance of mathematics in everyday life. Meaningful learning experiences are expected to foster more positive attitudes toward mathematics. Overall, the results demonstrate that Ethnomathematics-Integrated RME is effective in improving students' mathematical communication skills. The statistically significant improvement and changes in students' learning behavior indicate that this approach has strong potential for broader implementation. Continuous implementation supported by well-designed instructional materials is expected to produce more optimal improvements in the quality of mathematics learning at the junior high school level.

D. CONCLUSION AND SUGGESTIONS

This study concluded that the Ethnomathematics-integrated RME approach was effective in improving students' mathematical communication skills. The effectiveness of the approach was reflected in the increase in students' posttest scores compared to the pretest results, indicating significant improvement after the learning intervention. Students demonstrated improved abilities in expressing mathematical ideas, using mathematical symbols and representations appropriately, and systematically explaining solution procedures. This improvement was supported by several instructional characteristics of the integrated ethnomathematics-realistic

mathematics education approach, including the use of contextual and culturally relevant learning situations, active student participation, collaborative discussions, and opportunities for students to present and reflect on their mathematical thinking. These learning experiences created a more meaningful learning environment and encouraged students to communicate mathematical ideas more confidently and coherently.

Several limitations should be acknowledged in this study. The use of a relatively small sample and a one-group pretest-posttest design without a control group may reduce the generalizability of the findings and limit comparisons with other learning approaches. Furthermore, the study focused only on mathematical communication skills at the junior high school level within a limited research context. Based on these findings, mathematics teachers are encouraged to implement Ethnomathematics-Integrated RME as an alternative learning approach to improve students' mathematical communication skills through contextual and culturally relevant learning activities. Future research is recommended to involve larger samples, different educational levels, and more rigorous experimental designs to obtain broader and more comprehensive findings.

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