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ANALYSIS OF JUNIOR HIGH SCHOOL STUDENTS' MATHEMATICAL PROBLEM-SOLVING SKILLS IN HOTS TASKS BASED ON TOLAKI MEKONGGA LOCAL WISDOM

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ABSTRACT

Mathematical problem-solving is a crucial competence that enables students to think critically and creatively in facing real-life challenges. However, mathematics learning often lacks meaningful connections to students' cultural contexts. This study integrates local wisdom from the Tolaki Mekongga community as a culturally relevant approach to strengthen students' understanding of mathematical concepts. The study aims to describe and analyze junior high school students' mathematical problem-solving abilities through ethnomathematics-based problems derived from Tolaki Mekongga traditions. This research employed a descriptive qualitative design involving 32 eighth-grade students from SMP Negeri 2 Kolaka. Data were collected through problem-solving tests and interviews, then analyzed according to Polya's four stages: understanding, planning, implementing, and reviewing the solution. The findings revealed that most students demonstrated moderate to high levels of problem-solving ability. High-ability students could relate mathematical concepts to local cultural contexts, while low-ability students struggled to interpret contextual information and apply appropriate strategies. The study concludes that incorporating problems based on local wisdom enhances students' engagement and conceptual understanding. Integrating cultural contexts such as Tolaki Mekongga traditions can serve as an effective ethnomathematical approach for improving mathematical problem-solving skills and fostering culturally responsive mathematics learning.

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1. INTRODUCTION

Education plays a vital role in shaping quality human resources capable of responding to the growing challenges of the modern world characterized by rapid technological advancement and the increasing complexity of life. Among the various school subjects, mathematics occupies a central position because it trains students to think logically, analytically, systematically, and critically. Mathematics learning is not merely about memorizing formulas or performing calculations but also about developing reasoning, abstraction, and higher-order thinking skills that can be applied in solving real-life problems. Consequently, the ability to solve mathematical problems has become one of the key competencies students are expected to master, particularly at the junior high school level, where foundational reasoning skills are formed.

Polya conceptualized problem solving as a systematic thinking process consisting of four stages: understanding the problem, devising a plan, carrying out the plan, and looking back at the results Haris et al., (2025). These stages have long been used as a framework to assess students' mathematical thinking processes. However, in the context of modern education, effective problem solving requires more than procedural understanding-it demands critical, creative, and reflective thinking. This perspective aligns with the goals of the current curriculum in Indonesia, which emphasizes the development of Higher-Order Thinking Skills (HOTS) that include the abilities to analyze, evaluate, and create Chabibah et al., (2019). HOTS-oriented learning aims to prepare students not only to comprehend mathematical concepts but also to apply them flexibly to new and unfamiliar contexts.

Despite the growing emphasis on HOTS-based instruction, empirical evidence indicates that the implementation of HOTS-oriented mathematics learning in Indonesia remains suboptimal. Many students experience difficulties when faced with non-routine or reasoning-based problems that require deeper conceptual understanding and logical connections Aziz & Jupri, (2025). Teachers, on the other hand, still encounter challenges in designing and developing learning instruments and test items that reflect HOTS characteristics and are contextually relevant to students' real-life situations (Ismail et al., 2024; Solihin et al., 2025). These challenges highlight a persistent gap between curriculum expectations and classroom practices. Therefore, innovation is needed to design learning experiences that are not only cognitively demanding but also meaningful and contextual to students' everyday lives.

One promising approach to address this gap is the integration of *local wisdom* or cultural elements into mathematics learning. Local wisdom refers to the collective knowledge, values, and life practices of a community that have been transmitted across generations and remain relevant to local contexts Selasih & Sudarsana, (2018). Integrating local culture into mathematics learning enables students to relate abstract mathematical concepts to familiar experiences in their surroundings. For instance, activities in trade, agriculture, architecture, or traditional crafts can serve as culturally meaningful contexts for mathematical exploration (Gerdes, 1999; Kumar & Gopinath, 2025). Through such contextualization, students not only develop conceptual understanding but also strengthen their cultural identity and appreciation for local heritage.

Within the cultural setting of the Tolaki Mekongga community in Southeast Sulawesi, Indonesia, numerous forms of local wisdom can serve as authentic contexts for learning mathematics. One of these is the *Tabere* decorative motif commonly found in traditional houses. The *Tabere* motif consists of symmetrical, repetitive geometric patterns that reflect the Tolaki community's values of harmony, persistence, and continuity of life. It symbolizes strength, togetherness, and the collective spirit of maintaining cultural traditions. From a mathematical perspective, the motif exhibits regularity similar to an arithmetic sequence, where the elements repeat at consistent intervals. Thus, beyond its aesthetic and symbolic meaning, the *Tabere* motif represents a rich ethnomathematical object through which students can explore mathematical ideas such as patterns, regularity, and numerical relationships.

An illustration of the *Tabere* motif used in this study is presented in Figure 1. The motif is used as a visual context for developing HOTS-oriented problem-solving tasks.

From the tabere motif image, there are several motifs, including:

Left-facing tabere motif Tabere root motif Right-facing tabere motif

Figure 1. Tabere Motif of the Tolaki Mekongga Community

By using culturally rooted contexts such as the *Tabere* motif, mathematics learning can be transformed into an experience that connects students' cultural background with abstract reasoning processes. This approach not only facilitates conceptual comprehension but also fosters character values such as pride, appreciation, and responsibility toward local heritage. Several researchers have emphasized that contextual learning based on local culture contributes positively to students' engagement and critical thinking Yuliani & Rahman, (2023). In this regard, integrating Tolaki Mekongga local wisdom into mathematical problem-solving tasks is expected to serve a dual purpose: enhancing students' HOTS and preserving indigenous knowledge.

However, studies explicitly analyzing students' mathematical problem-solving abilities within HOTS problems that incorporate the Tolaki Mekongga local cultural context remain scarce. Previous ethnomathematics studies in Indonesia have largely focused on other cultural settings, such as Batak, Javanese, or Bugis traditions, leaving a research gap in exploring the mathematical richness embedded in Tolaki Mekongga culture. Consequently, the exploration of this particular context is both relevant and significant. It contributes to broadening the ethnomathematical landscape in Indonesia and provides empirical insights into how cultural integration influences students' problem-solving skills.

Based on the above considerations, this study aims to analyze junior high school students' mathematical problem-solving abilities in solving HOTS-oriented problems that integrate elements of Tolaki Mekongga local wisdom. Through this investigation, it is expected that a detailed profile of students' problem-solving performance can be obtained, revealing their strengths and weaknesses in addressing culturally contextualized tasks. The findings are anticipated to contribute to the development of more meaningful, contextual, and culture-responsive mathematics learning models that support not only academic competence but also character formation and cultural preservation.

2. METHOD

This study employed a descriptive qualitative design Creswell, (2018), as it aimed to explore and describe in depth the mathematical problem-solving abilities of junior high school students in addressing Higher Order Thinking Skills (HOTS) problems contextualized with Tolaki Mekongga local wisdom. The qualitative approach allowed the researcher to capture students' reasoning, cognitive, and metacognitive processes as they engaged with mathematical problems embedded in culturally meaningful contexts.

2.1 Research Setting and Participants

The research was conducted at SMP Negeri 2 Kolaka, located in Kolaka Regency, Southeast Sulawesi Province, during the odd semester of the 2025-2026 academic year. This school was purposefully selected because it integrates local cultural values into the learning process and represents students who are familiar with Tolaki Mekongga traditions.

A total of 32 eighth-grade students participated in the study. Participants were selected using purposive sampling based on their prior exposure to HOTS-oriented mathematics material and varied academic performance. This diversity enabled the researcher to obtain a richer understanding of students' differing levels of problem-solving ability. Based on the initial test results, three students were selected for in-depth interviews, each representing one of three ability levels-high, moderate, and low-to ensure diverse perspectives and reasoning strategies were captured.

2.2 Data Types and Sources

The study utilized both primary and secondary data.

- Primary data were obtained from students' written responses to mathematical problem-solving tests and semi-structured interviews.
- Secondary data included observations, documentation, and field notes taken during classroom activities.

The main data source was eighth-grade students, while supporting data were obtained from mathematics teachers and expert validation reports. Primary data provided direct evidence of students' performance, whereas secondary data supported contextual interpretation and triangulation.

2.3 Research Instruments

The researcher served as the primary instrument (*human instrument*), responsible for planning, implementing, and interpreting the research process. Two supporting instruments were used:

1. A HOTS-based mathematical problem-solving test, and
2. A semi-structured interview guide.

The problem-solving test consisted of four open-ended questions developed according to (Polya, 1973) four stages of problem-solving: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) reviewing the solution. Each question was contextualized using Tolaki Mekongga cultural elements, such as the *tabere* decorative motif and traditional house geometry, to make the problems more meaningful and relevant to students' real-life experiences.

The interview guide was designed to elicit students' reasoning processes, challenges encountered, and their ability to connect mathematical ideas with the presented cultural context.

2.4 Instrument Validation and Pilot Testing

Prior to implementation, the instruments were validated by two mathematics education experts from Universitas Sembilanbelas November Kolaka. The validation process employed content validity analysis, focusing on three aspects: (a) the relevance of content, (b) linguistic clarity, and (c) the appropriateness of the level of difficulty for eighth-grade students. Feedback from experts was incorporated to refine the instruments.

A pilot test was conducted with a small group of students outside the research sample to ensure clarity and comprehension. Necessary revisions were made based on the pilot findings to enhance the instruments' reliability and readability before final administration.

2.5 Data Collection Procedures

Data were collected over a four-week period through three sequential stages:

1. Administering the mathematical problem-solving test to all 32 participants;
2. Conducting in-depth interviews with three selected students representing each ability level; and
3. Documenting students' written responses and classroom interactions related to the research focus.

All procedures adhered to ethical research standards, including informed consent and confidentiality agreements.

2.6 Data Analysis Techniques

Data were analyzed using the interactive model of Miles & Huberman, (1994), which involves three concurrent stages:

1. Data reduction–selecting, organizing, and simplifying data relevant to indicators of mathematical problem-solving ability;
2. Data display–organizing data into tables, narratives, and excerpts from student interviews; and
3. Conclusion drawing and verification–identifying emerging patterns, interpreting meanings, and validating conclusions through iterative analysis.

The unit of analysis consisted of students' written responses and verbal explanations aligned with Polya's problem-solving stages. To ensure the credibility and trustworthiness of findings, data triangulation, member checking, and peer debriefing were employed, consistent with Lincoln and Guba & Lincoln, (1985) criteria of credibility, dependability, and confirmability.

2.7 Categorization of Mathematical Problem-Solving Ability Levels

Students' problem-solving abilities were categorized using modified criteria from Arikunto, (2022) to facilitate interpretation of performance levels. The categorization is presented in *Table 1*.

This categorization served as the analytical reference for classifying students' abilities into high, moderate, and low levels. It also guided the selection of interview participants and the interpretation of variations in students' reasoning when solving culturally contextualized HOTS problems.

Table 1. *Categories of Mathematical Problem-Solving Ability Levels*

Value Range	Category
67 – 100	High
34 – 66	Moderate
0 – 33	Low

3. RESULTS AND DISCUSSION

3.1. Results

This study aims to describe the mathematical problem-solving abilities of eighth-grade students at SMP Negeri 2 Kolaka in solving Higher Order Thinking Skills (HOTS) problems based on Tolaki Mekongga local wisdom. The research data were obtained through a mathematical problem-solving ability test taken by 32 students and in-depth interviews with three students representing high, medium, and low ability categories. Data analysis was conducted based on Polya, (1973) four stages of problem solving, namely understanding the problem, planning the solution, implementing the plan, and reviewing the results.

3.1.1 Mathematical Problem-Solving Ability Test Results

Based on the results of the mathematical problem-solving ability test, the data shown in the following table was obtained.

Table 2. Mathematical Problem-Solving Ability Test Results

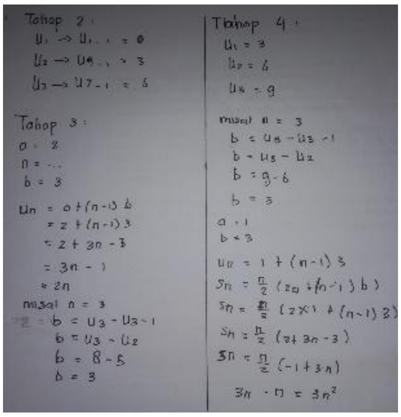
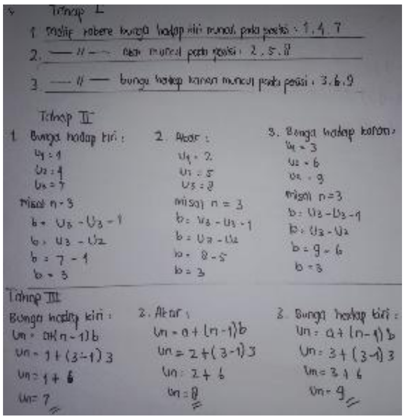
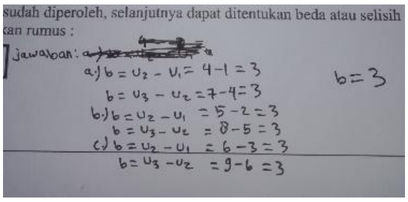
Kategori	Frekuensi	Persentase %
High	23	71,9%
Moderate	8	25,0%
Low	1	3,1%
Number	**32**	**100%**

Based on the table above, it is evident that most students fall into the high category. This indicates that students have been able to understand the context of the problem and apply mathematical concepts in solving problems based on Tolaki Mekongga local wisdom, particularly in the tabere motif pattern.

3.1.2 Analysis of Mathematical Problem-Solving Ability Based on Polya's Stages

To gain a deeper understanding of students' mathematical problem-solving abilities at each level, an analysis was conducted based on Polya's problem-solving stages. This analysis aimed to determine how students understand problems, plan, execute, and review their solutions. The results of this analysis are summarized in Table 2 below.

Table 3. Analysis of Mathematical Problem-Solving Ability Based on Polya's Stages

Student Category	Polya's Stage	Description of Ability	Remarks
High	Understanding the problem, planning a strategy, implementing the plan, and looking back (evaluation)	Able to understand the problem thoroughly, select an appropriate strategy, execute each step systematically and accurately, and review the results to ensure correctness. Demonstrates logical reasoning and a deep understanding of the problem context.	 Answers are correct, complete, and logical.
Moderate	Understanding the problem and planning a strategy	Able to understand the problem and design a strategy, but still makes minor errors in calculation or evaluation. Requires minimal guidance to maintain accuracy and consistency.	 Answers are mostly correct, with minor errors.
Low	Understanding only part of the problem context	Experiences difficulty in understanding the problem, selecting the proper strategy, and applying the correct solution steps. Shows frequent procedural mistakes and incomplete reasoning.	 Answers are incomplete or incorrect.

Based on Table 3, it can be seen that students in the very high and high categories were able to follow all stages of Polya's process well and systematically. Meanwhile, students in the moderate to very low categories still experienced difficulties, especially in the planning and checking stages.

3.1.3 Summary Based on Ability

In this study, students' mathematical problem-solving abilities were categorized into three levels: high ability, moderate ability, and low ability. This classification aims to provide a clearer picture of the characteristics of students in dealing with mathematical problems, as well as to determine the appropriate form of intervention or assistance from teachers.

A summary of the characteristics of each category of students and the level of teacher intervention required is presented in the following table.

Table 4. Summary Based on Ability

Student Category	General Characteristics in Problem Solving	Level of Teacher Intervention
High Capability	Independent, analytical, reflective, and able to explain the mathematical reasoning behind their answers.	Minimal just give them enrichment or a variety of challenging questions.
Moderate Ability	Understands basic concepts but needs scaffolding to connect concepts to procedures.	Moderate needs step-by-step feedback
Low Ability	Focusing on procedures without understanding the concepts tends to lead to imitation.	High requires intensive guidance, discussion, and visualization.

3.1.4 Interview Results on Mathematical Problem-Solving Skills

Interviews were conducted with three students representing high, medium, and low ability categories with the aim of obtaining more in-depth information about how students understand problems, develop strategies, and implement solutions based on Polya's stages. The interviews were conducted after the test was given, without any additional learning or motivation from the researcher. The researcher only gave the questions and explored the students' thinking through open-ended questions.

The interview results showed that there were differences in thinking patterns between students with high, medium, and low abilities.

(1) High-Achieving Student

This student demonstrated a good understanding of the question and was able to explain the steps to solve it systematically. He said:

> *"First, I understand what is known and what is being asked. From the tabere motif image, I can see that the pattern repeats, so I use the number pattern formula to find the answer."*

This statement shows that the student is able to identify important information, understand the cultural context of the question, and relate it to relevant mathematical concepts. This student is also able to carry out the plan and check the results correctly, in accordance with Polya's steps.

(2) Average Ability Student

This student can understand most of the information in the question, but still has difficulty in implementing the plan. He said:

"I know what pattern is being asked, but when calculating, I am a little confused about which formula to choose."

This shows that the student already understands the core of the problem and is able to plan an initial strategy, but still lacks confidence in choosing the formula and applying it consistently. The errors that arise are mostly due to a lack of thoroughness in carrying out the steps to solve the problem.

(3) Low-ability students

Low-ability students still have difficulty understanding the meaning of the question and relating it to mathematical concepts. They say:

"I don't really understand the meaning of the question. I thought I just had to calculate the number, but the result was wrong."

This statement illustrates that students are not yet able to extract important information from questions and tend to immediately perform calculations without understanding the context of the problem. This results in the use of inappropriate solution strategies and incorrect results.

Overall, the interview results reinforce the findings from the test results. High-ability students were able to successfully complete all four stages of Polya's problem-solving process, from understanding the problem to checking the results. Students with average abilities tended to stop at the planning stage and were not yet proficient in implementation and checking. Meanwhile, students with low abilities still had difficulties from the problem understanding stage, so they were unable to determine the appropriate solution strategy. These findings show that students' mathematical problem-solving abilities are greatly influenced by their understanding of the context of the problem and their ability to relate information to the appropriate mathematical concepts.

3.2. Discussion

The findings of this study reveal that students' mathematical problem-solving abilities vary significantly across different ability levels-high, moderate, and low-when solving Higher Order Thinking Skills (HOTS) problems embedded with Tolaki Mekongga cultural contexts. These variations demonstrate not only differences in students' cognitive strategies but also the influence of contextual understanding on their ability to apply mathematical reasoning effectively. Overall, this discussion interprets the findings in light of Polya's problem-solving theory, ethnomathematical perspectives, and previous research on mathematical literacy and metacognition.

High-ability students successfully demonstrated mastery of all four stages of Polya, (1973) problem-solving process: understanding the problem, devising a plan, carrying out the plan, and looking back. These students showed analytical and reflective thinking skills in identifying essential information, selecting appropriate strategies, and verifying the correctness of their solutions. They were also capable of connecting mathematical problems to cultural contexts such as the *tabere* motif, which enhanced their conceptual understanding. This finding aligns with the notion of *contextualized cognition*, where students' familiarity with cultural artifacts supports deeper comprehension of mathematical structures Bishop, (1988). The ability of these students to link symbolic mathematical representations to real-world cultural patterns demonstrates that culturally relevant contexts can strengthen students' abstraction and reasoning skills.

In contrast, students with moderate abilities displayed an adequate understanding of problem situations and could formulate initial strategies but struggled with consistent execution and verification. Their difficulties primarily arose from uncertainty in formula selection and procedural inaccuracies. This indicates a partial mastery of conceptual knowledge but a lack of procedural fluency-consistent with Hiebert & Lefevre, (1986) distinction between *conceptual* and *procedural* understanding. These students require structured guidance or scaffolding to bridge their conceptual insights into consistent mathematical procedures. Similar patterns were observed by (Priyanti & Herman, 2021), who found that students often stagnate in the "planning" phase due to incomplete conceptual frameworks. Therefore, targeted interventions focusing on procedural reflection and metacognitive monitoring are necessary to help students strengthen their strategic competence.

Students in the low-ability group faced difficulties from the earliest phase of Polya's framework. They often misinterpreted problem statements, failed to identify key data, and attempted direct computation without prior analysis. This behavior indicates a lack of problem comprehension, which consequently disrupts subsequent stages of planning and implementation. According to Schoenfeld, (1985), failure at this stage is often associated with insufficient metacognitive control and weak mathematical schema activation. The inability of these students to connect cultural patterns (such as geometric sequences in *tabere* designs) to formal mathematical concepts also suggests limited cognitive transfer between informal cultural knowledge and formal mathematical reasoning.

These differences across ability levels substantiate Polya's assertion that successful problem solving is fundamentally rooted in a clear understanding of the problem itself. The data further supports findings from Sahliawati & Nurlaelah, (2020), who reported that most students' difficulties arise during the implementation and verification stages due to incomplete comprehension of relationships among problem components. In the present study, however, the challenge appears to emerge even earlier for low-ability students-during the comprehension stage-indicating that contextual understanding plays a pivotal role in mathematical cognition.

The integration of local cultural contexts, such as Tolaki Mekongga's *tabere* motifs, contributed positively to student engagement and problem comprehension. By embedding mathematical problems in familiar cultural narratives, students were able to interpret mathematical patterns through meaningful and tangible examples. This reflects the principles of ethnomathematics, as proposed by D'Ambrosio, (1985), which advocates for connecting mathematical learning with cultural practices to promote inclusivity and relevance. The use of local wisdom not only increases motivation but also provides cognitive scaffolds that make abstract mathematical ideas more concrete. Similar findings by Fitriani et al., (2023) confirmed that ethnomathematics-based learning environments enhance students' contextual reasoning and conceptual retention.

Furthermore, the findings underscore the critical role of reflective thinking and metacognitive awareness in improving students' problem-solving performance. High-ability students demonstrated active monitoring of their solutions, aligning with Flavell, (1979) concept of metacognition as "thinking about one's thinking." In contrast, moderate- and low-ability students exhibited limited self-regulation, often assuming correctness without verification. Developing metacognitive strategies-such as self-questioning, evaluation, and error analysis-can help learners internalize Polya's final step, "looking back," which is frequently neglected in conventional mathematics classrooms.

When viewed from a pedagogical perspective, these findings have several implications. First, mathematics teachers should emphasize comprehension and interpretation before computation, especially when introducing HOTS problems. Instructional strategies should encourage students to articulate problem contexts in their own words, thereby activating their prior knowledge and facilitating deeper understanding. Second, integrating ethnomathematical elements in classroom activities can serve as an effective means of contextualization, allowing students to bridge their cultural experiences with formal mathematical reasoning. Third, formative assessment techniques-such as reflective journals or guided problem-solving tasks-can help cultivate students' metacognitive habits and reduce procedural dependency.

In synthesis, this study extends previous research by highlighting that students' mathematical problem-solving ability is not only determined by cognitive competence but also by their capacity to contextualize and reflect. Students who can interpret cultural patterns mathematically tend to apply problem-solving steps more systematically and effectively. Conversely, those lacking contextual comprehension or reflective awareness struggle to construct logical solution paths. Thus, integrating Polya's theoretical model with ethnomathematical and metacognitive frameworks provides a more holistic understanding of students' mathematical problem-solving processes.

In conclusion, the findings affirm that the ability to connect contextual understanding with mathematical reasoning is a key determinant of problem-solving success. Embedding local cultural contexts into mathematical learning fosters meaningful engagement, enhances conceptual connections, and supports the development of higher-order cognitive and reflective skills. Therefore, teachers and curriculum developers should consider incorporating culturally relevant and reflective pedagogies to improve students' mathematical literacy and problem-solving competence in diverse educational settings.

4. CONCLUSION

This study aimed to describe the levels of students' mathematical problem-solving abilities based on their mathematical literacy. The findings revealed variations in students' abilities across Polya's four stages-understanding the problem, planning the solution, implementing the plan, and checking the results. High-ability students successfully completed all stages, demonstrated strong analytical skills, and effectively connected cultural contexts such as *tabere* motifs to mathematical concepts. Students of moderate ability showed partial mastery of problem-solving processes, particularly struggling in execution and verification, often due to inaccuracy and inconsistency. Meanwhile, low-ability students had difficulty identifying key information and selecting appropriate strategies, indicating insufficient comprehension in the initial phase of problem-solving.

These patterns confirm that students' success in problem solving is strongly influenced by their understanding of the contextual meaning of problems and their ability to apply Polya's framework systematically. The results also reinforce Polya, (1973) theory and are consistent with studies by Priyanti & Herman, (2021) and Sahliawati & Nurlaelah, (2020), highlighting that reflective and contextual thinking are critical for improving mathematical reasoning.

The integration of local cultural contexts, such as *tabere* motifs, was found to enhance engagement and conceptual understanding, supporting the ethnomathematical approach as a culturally responsive pedagogy. Therefore, mathematics learning should focus on strengthening conceptual comprehension, analytical reasoning, and reflective thinking through culturally relevant contexts. Future research could explore the design and validation of ethnomathematics-based learning modules to further enhance students' mathematical literacy and problem-solving abilities.

Overall, this study contributes to a deeper understanding of how mathematical literacy and cultural contexts shape students' cognitive processes in mathematics learning and offers practical insights for educators aiming to improve problem-solving competence through contextualized instruction.

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