Meta Synthesis: Ethnomathematics-Based PISA Questions on Secondary School Students' Mathematical Literacy

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Abstract

Mathematical literacy is one of the skills assessed in the PISA test. The results of the PISA international assessment show that Indonesian students' mathematical literacy skills are not yet optimal. An effort to evaluate suboptimal mathematical literacy is to use questions with an ethnomathematics-based PISA framework. This study aims to synthesize various studies discussing ethnomathematics-based PISA questions used to assess the mathematical literacy of secondary school students. The research method used is a Literature Review with meta-synthesis techniques, which analyzes five selected articles published in 2020–2025 from the Scopus, Google Scholar, and Semantic Scholar databases. The inclusion criteria focused on qualitative studies with junior high and high school students as subjects that discussed mathematical literacy skills through a cultural context. The results of the study show that local cultural elements such as traditional food, Sidoarjo batik, and Gambang musical instruments are effective contextual media in connecting mathematical concepts with students' real lives. The most frequently appearing indicators of mathematical literacy are communication and mathematizing, while the indicators of reasoning and argument remain a major challenge for students. PISA questions with an ethnomathematics nuance are able to strengthen students' understanding of mathematics and instill local cultural values, thereby improving mathematical literacy. Thus, the integration of local culture in mathematics learning is an effective strategy for strengthening mathematical literacy skills and instilling cultural awareness in students in accordance with the PISA framework.

Keywords: PISA, ethnomathematics, mathematical literacy.

Introduction

Mathematical literacy reflects how students can apply mathematical concepts, procedures, and reasoning in various everyday situations (Amidi et al., 2025). Mathematical literacy is one of the skills assessed in the PISA test (Malanua et al., 2024). The PISA test, especially in mathematical literacy, uses internationally standardized questions that raise issues in everyday life and relate them to mathematics (Yudha et al., 2025). The 2018 PISA framework is divided into three main components to measure mathematical literacy, namely content, process, and context. The process component includes the stages of formulating, employing, and interpreting. This process also encompasses seven indicators of mathematical literacy, such as communication; mathematizing; representation; reasoning and argument; devising strategies for solving problems; using symbolic, formal, and technical language and operations; and using mathematical tools (OECD, 2019).

The PISA 2018 framework is relevant to the Indonesian educational context because the competencies assessed within this framework constitute essential prerequisites for students' problem-solving abilities (Pratama & Yelken, 2024). A major challenge arises when students are confronted with contextual problems that reflect real-life situations. Therefore, a systematic instructional approach is required to strengthen students' conceptual understanding of mathematics, enabling them to apply mathematical knowledge effectively in solving contextual problems.

The results of the PISA international assessment show that Indonesian students' mathematical literacy skills are in the bottom quartile (OECD, 2023b). This fact indicates that students in Indonesia have not mastered aspects of mathematical literacy. These low achievements show that the majority of students in Indonesia do not yet understand the conceptual meaning of a problem. Therefore, mathematics learning needs to be developed so that there is continuity between mathematical concepts and phenomena in everyday life (Rodríguez-Nieto et al., 2023). An alternative that can be chosen to bridge this gap is the application of ethnomathematics (Yanti, 2025).

Culture can be used as a reference in mathematics learning through the integration of ethnomathematics (Yumnanika & Waluyo, 2024). The application of ethnomathematics facilitates critical thinking processes, as students are required to interpret mathematical concepts through their understanding of the function of mathematics in life (Syahnia et al., 2024). The use of problems related to culture can be a means of measuring the extent to which students are able to apply mathematical concepts in real life (Sari et al., 2023). thnomathematics enables students to construct conceptual meaning more easily because it allows them to connect mathematical symbols and models with their existing social experiences. This condition indicates that an ethnomathematics-based approach has significant potential in supporting the improvement of students' mathematical literacy. These findings are consistent with previous studies by Zaenuri et al. (2020) and Hanum et al. (2020), which conclude that ethnomathematics-based learning is effective and contributes positively to the enhancement of students' mathematical literacy..

One reference that can be used to evaluate mathematics learning in mathematical literacy is to use questions with an ethnomathematics-based PISA framework. This approach is in line with Balán (2025) that the PISA framework integrates mathematical abilities and environmental competencies through a sustainable understanding of social, cultural, and economic issues. PISA-based tasks developed through an ethnomathematics

approach can be integrated with the cultural diversity of Indonesia (Lestari & Wulantina, 2024). Several studies have examined the implementation of PISA tasks within local Indonesian cultural contexts, such as Prahmana & D'Ambrosio (2020) , who employed the context of Yogyakarta; Dasaprawira et al. (2019) , who utilized the cultural context of Bangka; and Zaenuri et al. (2020) , who incorporated Demak culture. This approach makes mathematics learning more relevant to students' lived experiences, thereby helping them connect abstract concepts with real-life situations and deepen their mathematical understanding (Puspadewi et al., 2025). In addition, the integration of cultural elements into mathematics learning contributes to fostering students' sense of pride and appreciation for Indonesia's cultural heritage.

Several studies have been conducted on the use of ethnomathematics-based PISA questions to assess mathematical literacy, such as Lestari & Wulantina (2024) using the context of traditional food, Manoy & Purbaningrum (2021) using the context of Batik Sidoarjo, dan Yumnanika & Waluyo (2024) using the Gambang musical instrument. These studies concluded that ethnomathematics-based PISA questions have a positive effect on students' mathematical literacy. Teachers can use this to adapt the PISA questions used to their respective local cultures in order to improve students' mathematical literacy.

Although a number of studies have examined ethnomathematics-based PISA tasks in the context of mathematical literacy assessment, most of these studies remain partial and focus on specific cultural contexts. To date, there has been no literature review that synthesizes qualitative findings from these studies to identify general patterns, strengths, and limitations of the application of ethnomathematics within the PISA framework. Therefore, this study aims to address this research gap through a literature review employing a meta-synthesis approach, in order to develop a more comprehensive understanding of the role of ethnomathematics-based PISA tasks in secondary school students' mathematical literacy. Accordingly, this study is expected to contribute novelty by presenting an integrated conceptual synthesis that can serve as a foundation for the development of culturally responsive mathematics learning and assessment.

Method

This article employs a literature review method with meta-synthesis techniques to address the research questions by systematically integrating findings from previously published and methodologically valid studies (Raharani et al., 2024). Meta-synthesis is

used to interpret and combine qualitative findings across studies in order to generate higher-level conceptual insights that go beyond individual study results (Nurhalisha et al., 2025; Rohmah & Kartono, 2025). Unlike primary data collection, this approach reprocesses existing qualitative evidence through thematic interpretation to develop a more comprehensive and in-depth understanding of the research phenomenon.

This approach is grounded in the principle that the synthesis of qualitative research should be conducted in a systematic and transparent manner in order to generate meaningful conceptual understanding, rather than merely providing a narrative summary of previous studies (Nurhalisha et al., 2025). The stages of the literature review were designed to support the analytical process using a meta-synthesis technique.

The first stage involved the formulation of research questions, which included: (R1) the research subjects, (R2) the cultural contexts employed, (R3) the main research findings, and (R4) the relationship between ethnomathematics-based PISA tasks and secondary school students' mathematical literacy. The formulation of these research questions aimed to focus the scope of the review and ensure the coherence of the synthesis process.

The second stage consisted of a literature search conducted through several relevant digital databases, namely Scopus, Google Scholar, and Semantic Scholar, to identify studies aligned with the focus of the review. The Web of Science database was not included because this study adopts a meta-synthesis approach that prioritizes conceptual depth and the achievement of conceptual saturation rather than exhaustive database coverage. Accordingly, database selection was based on accessibility and the substantive relevance of the studies to the research objectives.

The subsequent stage involved the screening and selection of articles through a review of titles and abstracts, followed by the application of inclusion and exclusion criteria to ensure the quality and relevance of the analyzed studies. The validity of the findings was ensured through the application of strict selection criteria, assessment of the methodological quality of the articles, and a transparent meta-synthesis process involving thematic coding and the development of analytical themes (Thomas & Harden, 2008). The inclusion and exclusion criteria are presented in Table 1.

Table 1. Inclusion and Exclusion Criteria

	Inclusion Criteria	**Exclusion Criteria**
Year of publication	2020-2025	Before 2020
Publication type	Article publications from indexed journals	Publications other than articles
Identity	Clear identity with author, year of publication, and publisher	Unclear identity with only one of the author, year of publication, and publisher
Article theme	Ethnomathematics-based PISA questions on mathematical literacy	Other than ethnomathematics-based PISA questions on mathematical literacy
Research Method	Qualitative method	Other than qualitative method
Education Level	Junior High School, Senior High School	Early Childhood Education, Elementary School, Higher Education

The subsequent stage involved the analysis and synthesis of qualitative findings using a meta-synthesis technique. This process was conducted through thematic coding of the key findings from each selected article, the grouping of codes into descriptive themes, and the development of analytical themes to interpret relationships and patterns across studies. Through these stages, the meta-synthesis not only compiles findings from previous research but also generates higher-level conceptual understanding that extends beyond the results of individual primary studies (Thomas & Harden, 2008).

The final stage involved the presentation and summarization of the synthesized findings, which were reported as the results of a meta-synthesis-based literature review to address the research questions in a systematic and integrated manner. Overall, the sequence of research stages is illustrated in Figure 1 to provide a comprehensive overview of the research process.

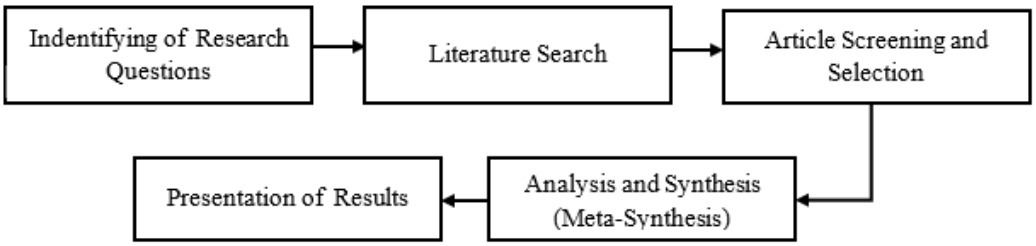

Figure 1. Research Stages

The digital library stage was carried out using the Publish or Perish application. Next, the research results were screened by entering the keywords “mathematical literacy

AND ethnomathematics" in the range of 2020-2025. The screening stage yielded 4 articles from Scopus, 87 from Google Scholar, and 149 from Semantic Scholar, for a total of 240 articles. The 240 articles obtained were then selected based on inclusion and exclusion criteria to ensure high quality. The article search stage to obtain high-quality articles used the PRISMA diagram, which can be seen in Figure 2.

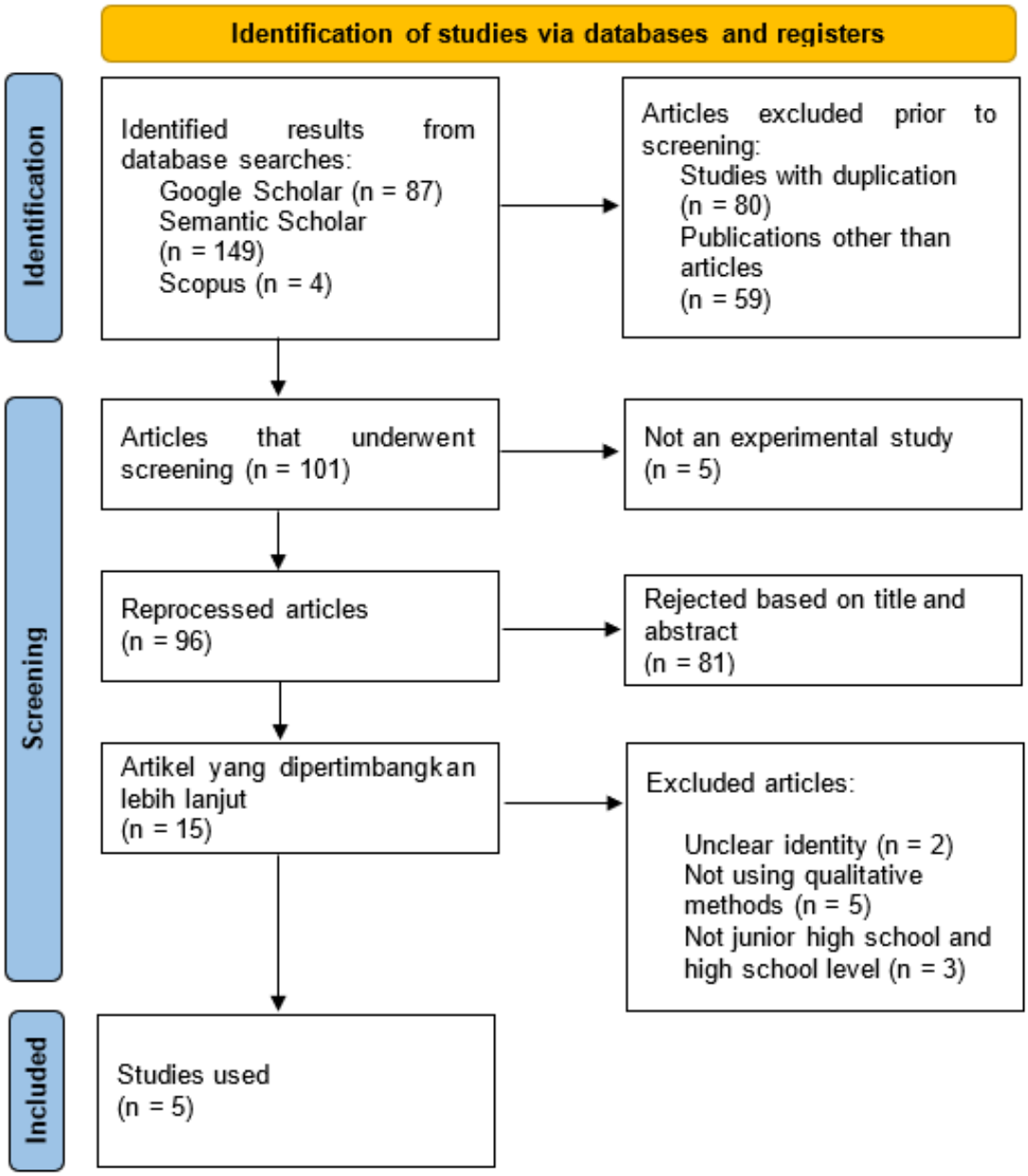

Figure 2. Article Search Process

Results and Discussion

The quality of the selected articles was assessed based on the clarity of research objectives, methodological rigor, relevance to ethnomathematics-based PISA tasks and mathematical literacy, as well as the completeness of reported findings. The limited

number of included studies reflects the application of strict inclusion criteria and the specific focus of the review, rather than a lack of available research. Based on the search and selection process, five high-quality articles were identified, analyzed in this study, and presented in Table 2.

Table 2. Articles used for review

No	Author	Journal	Title
1	Lestari & Wulantina (2024)	Unnes Journal of Mathematics Education (Sinta 3)	Analysis of Mathematical Literacy in Solving PISA Questions Based on Ethnomathematics in Junior High School Students
2	Sulistiawati et al. (2024)	Journal of Medives (Sinta 3)	Analysis of Students' Mathematical Literacy Ability in Solving Ethnomathematical Problems on SPLDV Material Judging from Student Learning Interests
3	Kurniati & Mariani (2020)	Unnes Journal of Mathematics Education (Sinta 3)	Qualitative analysis on mathematical literacy ability and student responsibility with realistic mathematics education learning models of ethnomathematics nuance
4	Manoy & Purbaningrum (2021)	Jurnal Didaktik Matematika (Sinta 2)	Mathematical Literacy Based on Ethnomathematics of Batik Sidoarjo
5	Yumnanika & Waluyo (2024)	Jurnal Manajemen Pendidikan dan Ilmu Sosial (JMPIS) (Sinta 3)	Analisis Kemampuan Literasi Matematika dalam Menyelesaikan Soal PISA Berbasis Etnomatematika Gambang

The data extraction process was conducted by organizing information from each selected article into tabular form to facilitate cross-study comparison and analysis. The variables extracted included the research subjects, the cultural contexts employed, the mathematical literacy indicators examined, and the key findings related to students' mathematical literacy. These variables were then synthesized through comparative analysis to identify patterns, general trends, and major challenges in the implementation of ethnomathematics-based PISA tasks in relation to secondary school students' mathematical literacy. The synthesized results are concisely presented in Table 3.

Table 3. Article Results Based on Research Questions

No	Title	RQ1	RQ2	RQ3
1	Analysis of Mathematical Literacy in Solving PISA Questions Based on Ethnomathematics in Junior High School Students	9 students from 3 junior high schools in Batanghari	Traditional foods	Junior high school students in Batanghari have mathematical literacy skills in solving PISA questions
2	Analysis of Students' Mathematical Literacy Ability in Solving Ethnomathematical Problems on SPLDV Material Judging from Student Learning Interests	3 out of 29 eighth-grade students at SMPN 16 Surakarta with high, medium, and low learning interests	Traditional foods	Students with high and medium learning interests are able to meet mathematical literacy indicators well. Students with low interest in learning still need to improve their mathematical literacy.
3	Qualitative analysis on mathematical literacy ability and student responsibility with realistic mathematics education learning models of ethnomathematics nuance	6 students in grade VIII at SMP 40 Semarang with high, medium, and low levels of responsibility.	Central Java traditional foods	The students' responsibility categories are in line with the mathematical literacy indicators that were met.
4	Mathematical Literacy Based on Ethnomathematics of Batik Sidoarjo	5 students in grade 10 at SMA N 1 Sidoarjo	Batik Sidoarjo	The overall mathematical literacy of students in working on Sidoarjo batik ethnomathematics questions is inadequate.
5	Analisis Kemampuan Literasi Matematika dalam Menyelesaikan Soal PISA Berbasis Etnomatematika Gambang	35 students from SMA Negeri 1 Geyer.	Gambang musical instrument	Based on mathematical literacy indicators, subjects in the high group met 6 indicators, subjects in the medium group met 4 indicators, and subjects in the low group only met 2 indicators.

The subjects of the first to third articles were junior high school students, with 9 students from 3 junior high schools in the first article, 3 students in the second article, and 6 students in the third article. In addition, the research subjects in the other two articles

used high school students, with 5 students in the fourth article and 35 students in the fifth article. This is in accordance with mathematics, which is one of the compulsory subjects in the national curriculum from elementary to secondary level (Sa'adah & Utami, 2025). Furthermore, the ages of the junior high school and high school students studied were in line with the PISA test, which was conducted on 15-year-olds. PISA assesses the extent to which 15-year-old students have acquired the knowledge and skills necessary to participate fully in modern society (OECD, 2023a).

PISA questions with cultural contexts that are more familiar to students' daily lives tend to result in a deeper understanding of mathematics among students. Based on the articles reviewed, there were two articles using the context of traditional food, one article using the context of Sidoarjo batik, and one article using the context of Gambang musical instruments. The cultures used are close to students' daily lives. The use of cultural contexts in PISA questions enables students to examine problems and communicate their opinions well and accurately in accordance with mathematical literacy indicators. In addition, students are also able to solve these problems because they feel close to the problems given. The application of culture in the PISA questions used is able to bridge the gap between students' cultural experiences and their mathematical concepts as part of mathematical literacy based on knowledge of their socio-cultural environment (Prihatiningtyas & Buyung, 2023).

The different cultural contexts used result in students having different meaningful understandings of mathematics. In the study, the use of the Gambang musical instrument in the PISA questions made it easier for students to understand arithmetic sequences, arithmetic series, spatial figures, and social arithmetic. Furthermore, the use of traditional food in PISA questions made students think more contextually and realistically. Students were able to relate numerical data on food ingredients to mathematical operations, create questions using mathematical models, and understand SPLDV. Conversely, the ethnomathematics context using batik required greater geometric abstraction skills to understand the geometric patterns and shapes in batik motifs. In a study using Sidoarjo batik motifs, students were able to understand the transformations found in batik designs. Thus, each cultural context used has its own advantages in improving mathematical literacy. The differences in ethnomathematics contexts used in PISA questions influence students' understanding of the problems given (Umbara et al., 2023). Integrating ethnomathematics enables students to build a multicultural context for developing

mathematical knowledge and skills and helps students connect with scientific disciplines (Maulina et al., 2024)

In the study of the articles, affective factors were considered in applying ethnomathematics-based learning. The affective factor considered was learning interest. Learning interest is a motivating factor for students in learning based on their liking or desire to learn (Okeke et al., 2023). High learning interest can be built by making students aware that learning will bring progress for themselves, especially in learning mathematics (Friantini & Winata, 2019). Students' high learning interest in mathematics has an impact on their learning achievements in mathematics lessons (Okeke et al., 2023).

In addition to considering affective aspects, the reviewed articles also emphasize the importance of optimally integrating learning models with ethnomathematics nuances. As the literature review shows, there is a Realistic Mathematics Education (RME) model that supports the integration of ethnomathematics. The RME model focuses on contextual problem solving related to students' lives as the core of learning (Maslihah et al., 2021). Learning with the RME model integrated with ethnomathematics is very well applied to improve students' mathematical literacy and responsibility. The RME model is able to foster a sense of responsibility in students by accustoming them to behave as a reflection of responsibility, thereby improving their mathematical literacy (Kurniati & Mariani, 2020).

Based on the results of the fifth study, the five articles show that the ethnomathematics-based PISA questions used produce different levels of mathematical literacy among secondary school students. These differences are classified into three categories: high, medium, and low. Students in the high category were able to understand the contextual problems given, identify important information, and use mathematical concepts appropriately. They were able to connect mathematical concepts with the culture presented in the questions and provide strong arguments and reasoning. Students in the medium category showed that they were able to understand part of the questions and could compile the steps to solve them, but they still often made mistakes in the process. They find it difficult to connect the cultural context with mathematical concepts as a whole, so they are less thorough and unable to provide logical reasons. Meanwhile, students in the low category experience significant obstacles in understanding the questions, especially in cultural contexts that are unfamiliar to them. Students find it difficult to convert problems into mathematical models, so they misinterpret information, make mistakes in the process, and are unable to provide logical reasons.

The indicators in PISA questions with an ethnomathematics nuance that most often appear in the mathematical literacy of secondary school students are communication and mathematizing. The Communication indicator understood by students shows that students are able to write down the information known and asked in the question correctly, while mathematizing shows that students are able to create mathematical models and provide explanations correctly. Students acquire the communication indicator through their understanding of the problems given, especially if they are related to everyday life(Kholid et al., 2022). In the mathematising indicator, students are able to identify variables based on the real problems given (Yumnanika & Waluyo, 2024). Conversely, the reasoning and argument indicator remains a major challenge for students. This indicator enables students to read the context of the problem and reason by providing solutions to arrive at conclusions by presenting arguments. The ability to reason and argue is still lacking because these aspects require precision and an understanding of the problem in order to arrive at a conclusion (Lestari & Wulantina, 2024).

Ethnomathematics connects mathematics learning with students' local culture, motivates students, and provides a more realistic context. Ethnomathematics allows students to construct mathematical concepts as part of mathematical literacy based on their knowledge of socio-cultural fields (Pratama & Yelken, 2024). Ethnomathematics-oriented PISA questions not only measure calculation skills but also the ability to solve contextual problems that integrate local culture. The use of ethnomathematics-based PISA questions can be an effective means of improving mathematical literacy (Runtu et al., 2023). The development of ethnomathematics-based PISA questions can strengthen students' understanding of mathematics and instill local cultural values, thereby improving mathematical literacy (Kurniati MA et al., 2025)

Conclusion and Suggestion

Based on the results of a meta-synthesis of the five articles analyzed, it can be concluded that the application of PISA questions with an ethnomathematics nuance to secondary school students has been proven to be related to the mathematical literacy of secondary school students. The integration of local cultural contexts such as traditional foods, Sidoarjo batik, and Gambang musical instruments provides a contextual and authentic learning experience that strengthens the connection between mathematical concepts and students' real lives. The synthesis results show that the most dominant

literacy indicators achieved are communication and mathematizing, which describe students' ability to understand problems and build mathematical models. However, the reasoning and argument indicators remain a major challenge because they require more in-depth logical reasoning skills. In addition, affective factors such as learning interest and student responsibility have a significant effect on improving mathematical literacy. Thus, the development of PISA questions with an ethnomathematics nuance is a strategic approach in instilling cultural values while strengthening students' mathematical literacy in accordance with the PISA framework. Teachers are also expected to integrate local cultural elements into learning through contextual questions with an ethnomathematics nuance so that students can relate their daily experiences to mathematical concepts.

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