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Mathematical Literacy Among Indonesian Students: PISA Trends, Challenges, And Improvement Strategies

Ahyani Mirah Liani[1], Agusalim Juhari[2]

[1,2] Mathematics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, Makassar, Indonesia

Corresponding Author: ahyani.mirah.liani@unm.ac.id

Abstract

Indonesian students' mathematical literacy performance, as reflected in the Programme for International Student Assessment (PISA), remains below the average of OECD countries. The latest results indicate that Indonesia obtained a mathematics score of 364 in PISA 2025, compared with 366 in PISA 2022, a difference that was not statistically significant, while the OECD average reached 463. This situation highlights the importance of strengthening mathematics learning to develop students' ability to apply mathematical knowledge in real-world contexts. This article aims to examine Indonesia's mathematical literacy performance based on PISA results, analyze the alignment of selected learning strategies with the PISA mathematical literacy framework, and identify their implementation considerations in the Indonesian educational context. This study employed a qualitative approach through a literature review, drawing on OECD PISA reports and relevant previous studies. Five learning strategies were examined: Realistic Mathematics Education (RME), Problem-Based Learning (PBL), the flipped classroom, the integration of PISA-type questions, and the STEAM approach. The analysis indicates that these strategies offer different opportunities to engage students in the three mathematical literacy processes: formulating situations mathematically, employing mathematical concepts, facts, and procedures, and interpreting, applying, and evaluating mathematical results. However, their implementation depends on learning task design, teachers' competencies, and the availability of educational resources. The findings suggest that no single strategy serves as a universal solution; therefore, selecting and integrating learning strategies should be adapted to students' needs and school conditions. This review provides insights into the potential contributions and implementation considerations of various strategies for supporting mathematical literacy development in Indonesia.

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Keywords: Mathematical Literacy, PISA, Realistic Mathematics Education, Problem-Based Learning, Mathematics Learning Strategies, Indonesia.

INTRODUCTION

Mathematics is a fundamental field of knowledge that plays an important role in modern life. Mathematical skills are essential not only in academic contexts but also in everyday situations, such as making informed financial decisions, interpreting statistical information, and solving problems in various real-world contexts (OECD, 2023a).

The Programme for International Student Assessment (PISA), which is organized by the OECD every three years, is one of the most comprehensive benchmarks for assessing the mathematical literacy abilities of 15-year-old students from various countries in the world. The PISA assessment does not measure the ability to memorize formulas or complete algorithmic procedures per se, but rather measures the extent to which students are able to use mathematics functionally to formulate, apply, and interpret solutions in various real-life contexts (OECD, 2023a).

The results of the Programme for International Student Assessment (PISA) indicate that Indonesian students' mathematical performance remains below the OECD average. Indonesia's mathematics score declined from 386 in PISA 2015 to 379 in PISA 2018 and 366 in PISA 2022, before reaching 364 in PISA 2025. This score was considerably lower than the OECD average of 463 (OECD, 2026a). Furthermore, only 17% of Indonesian students attained at least Level 2 proficiency in mathematics, compared with 65% of students on average across OECD countries. In addition, almost no Indonesian students achieved Level 5 or 6 proficiency, whereas the OECD average was 8% (OECD, 2026b). These findings indicate that a large proportion of Indonesian students have not yet achieved the basic level of mathematical proficiency. Moreover, Indonesia's mathematics performance in PISA 2025 was not statistically significantly different from its performance in 2022 and remained below the level recorded in 2015 (OECD, 2026b).

Although Indonesia's mathematics performance in PISA 2022 declined compared with 2018, its relative ranking improved. This improvement in ranking should be interpreted cautiously because Indonesia's average mathematics score decreased from 379 in 2018 to 366 in 2022, while mathematics performance also declined across many participating countries (OECD, 2023b). The downward trend continued in PISA 2025, with Indonesia recording a mathematics score of 364, two points lower than in 2022 and considerably below the OECD average of 463 (OECD, 2026b). These findings indicate that improvements in relative rankings do not necessarily reflect improvements in students' actual mathematical proficiency.

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Therefore, strengthening students' mathematical literacy remains an important concern in improving the quality of mathematics education. One of the challenges in improving students' mathematical literacy is the need for learning approaches that encourage students to solve contextual problems and apply mathematical concepts in real-life situations. Previous studies have highlighted the importance of contextual teaching and problem-based learning in developing students' mathematical literacy skills (Hasanah et al., 2026). This kind of contextual thinking is what PISA is designed to measure.

PISA classifies students' mathematical literacy abilities into six tiered levels. Each level describes the competencies that students must master cumulatively. Table 1 summarizes the description of each level:

Table 1. PISA Mathematical Literacy Proficiency Levels

Level	Score Range	Category	Competency Description
Level 1	Under 420	Very Low	Answering questions within a very familiar context using information that is explicitly and directly available
Level 2	420–481	Basic	Interpreting and recognizing situations that require immediate action based solely on the available information
Level 3	482–544	Medium	Carry out established procedures, including those that require sequential and straightforward decisions
Level 4	545–606	Quite High	Working effectively with explicit models in concrete yet complex situations, allowing one to select and integrate various representations
Level 5	607–668	High	Developing and working with models of complex situations to identify constraints; reflecting on responses and communicating them
Level 6	669 and above	Very High	Conceptualizing generalizations and applying information based on investigations and modeling of highly complex situations

Source: OECD (2023a), adapted.

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METHOD

This research employs a qualitative approach using a literature review method. A qualitative approach was selected because this study aims to understand, analyze, and synthesize phenomena in depth through relevant scholarly literature, without collecting primary data in the field (Creswell & Creswell, 2023). A literature review is considered an appropriate research method for this study because it enables researchers to examine the development of existing knowledge, identify research gaps, and synthesize findings from previous studies to develop a meaningful contribution to the research topic (Snyder, 2024).

This research uses secondary data from the results of the PISA surveys published by the OECD, including the most recent PISA 2025 results. An understanding of historical trends in PISA scores is an important starting point before formulating improvement strategies. Table 2 presents the development of Indonesia's mathematics scores in the last five available PISA periods, along with a comparison with the OECD average:

Table 2. Development of Indonesian Mathematics Scores in PISA (2012–2025)

PISA Year	Indonesia's Score	OECD Average	Difference	Number of Participating Countries and Economies
2012	375	494	-119	65
2015	386	490	-104	72
2018	379	489	-110	79
2022	366	472	-106	81
2025	**364**	463	-99	91

Source: OECD (2014, 2016, 2019, 2023b, 2026b), compiled by the authors.

Table 2 shows that Indonesia's mathematics performance has remained below the OECD average across all five PISA assessment periods from 2012 to 2025. Indonesia recorded its highest mathematics score in 2015, at 386 points, before declining to 379 in 2018, 366 in 2022, and 364 in 2025. Although the difference between Indonesia's score and the OECD average narrowed from 119 points in 2012 to 99 points in 2025, Indonesia's mathematical performance remained substantially below the OECD average. Furthermore, the two-point difference between the 2022 and 2025 results was not statistically significant, indicating that Indonesia's mathematics performance had remained relatively unchanged during this period (OECD, 2026b).

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RESULTS AND DISCUSSION

This study examines five learning strategies that have the potential to enhance students' mathematical literacy in alignment with the PISA framework: (1) Realistic Mathematics Education (RME/PMRI), (2) Problem-Based Learning (PBL), (3) Flipped Classroom, (4) the Integration of PISA-Type Questions, and (5) the STEAM Approach. The analysis draws on relevant literature and focuses on two main dimensions. First, it examines the alignment of each strategy with the three mathematical literacy processes in the PISA 2022 framework: formulating, employing, and interpreting. Second, it reviews empirical findings from recent studies to identify evidence of the effectiveness of these strategies, particularly in the Indonesian educational context.

To provide an overview of previous research related to the learning strategies discussed in this study, Table 3 presents selected studies examining the relationship between various learning strategies and students' mathematical literacy. The studies are reviewed based on their learning strategies, educational contexts, and reported findings. This comparison provides a basis for identifying the contributions and limitations of previous research in supporting mathematical literacy development.

Table 3. Selected Studies on Learning Strategies and Mathematical Literacy

No.	Learning strategy	Researcher (year)	Educational context	Reported findings and relevance to mathematical literacy
1	Integrated PBL–PMRI with a math trail	Fauziyah et al. (2023)	Junior high school; Grade VIII	A mixed-methods study at SMP Negeri 1 Depok, Cirebon. The PBL model with a PMRI-based math trail was judged to meet the quality criteria for improving mathematical literacy. Students with high literacy met all six literacy indicators, those with moderate literacy met three, and those with low literacy met only one. Because the intervention combines several elements, the effect cannot be attributed to RME/PMRI alone.
2	Multiple intelligence	Natsir dan Munfarikhatin(2021)	Junior high school; Grade VIII (four students)	A qualitative descriptive study of four Grade VIII students, each with a different dominant intelligence, solving problems on change and relationships and on space and shape. The communication, mathematization, and

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				strategy-selection indicators were met differently across intelligence types. The study does not test PBL, so it is used here only to show that students' literacy differs between individuals.
3	Asynchronous numeracy learning	Patriana et al. (2021)	Elementary school; Grade V	A qualitative study at Muhammadiyah elementary schools in Surakarta on how numeracy is built into school activities through planning, implementation, and monitoring. Numeracy was delivered through synchronous and asynchronous learning and home visits. The study does not examine a flipped classroom or measure mathematical literacy, so it is not direct evidence for this strategy.
4	Integration of PISA-type questions	Syabaniah et al. (2025)	Junior high school; Grade VIII	A design research study (Tessmer model) at SMP Negeri 11 Palembang developed a PISA-type problem set with real-world contexts on number content. The set was rated very valid (82.9%) and practical (80%). Achievement was highest on formulating (80.8%), followed by employing (76.9%) and interpreting (70.6%), and interpretation and justification still needed improvement. The effect was inferred from descriptive results without a comparison group.
5	Literacy research review	Munfarikhatin et al. (2022)	Reviewed articles from national journals (2019–2021)	A literature study of 27 articles on Indonesian students' mathematical literacy after PISA 2018. Most used descriptive methods (52%), and the main topics were literacy profiles, the effects of learning models, and the development of learning tools such as modules. It describes the state of the research but does not test regular practice with PISA-type questions.

Source: Previous studies reviewed in this article, compiled by the authors (2026).

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presented in Table 3, previous studies relate to mathematical literacy in different ways. Fauziyah et al. (2023) examined an integrated PBL–PMRI model with a math trail, and Syabaniah et al. (2025) developed PISA-type questions. Natsir and Munfarikhatin (2021) and Munfarikhatin et al. (2022) describe students' literacy and the state of literacy research, and Patriana et al. (2021) report on numeracy practice in elementary schools, so these three do not test a learning strategy. Because the studies differ in context, design, and outcomes, their findings should be read according to each study's focus rather than as equivalent evidence of effectiveness. Taken together, they point to the value of tasks that ask students to apply mathematical concepts to contextual problems.

Analysis of Strategy Suitability with PISA Mathematical Literacy Process Components

Building on the findings of previous studies presented in Table 3, a further analysis is needed to examine how the identified learning strategies relate to the mathematical literacy processes defined in the PISA 2022 framework. These processes consist of formulating situations mathematically, employing mathematical concepts, facts, and procedures, and interpreting, applying, and evaluating mathematical results. Table 4 presents the authors' analytical synthesis of the potential contribution of each learning strategy to these three processes.

Table 4. Analysis of the Alignment of Learning Strategies with the PISA 2022 Mathematical Literacy Processes

Learning strategy	Formulating situations mathematically	Employing mathematical concepts, facts, and procedures	Interpreting, applying, and evaluating mathematical results	Overall analytical assessment
Realistic Mathematics Education (RME/PMRI)	Begins with meaningful real-world contexts. Students identify relevant information, assumptions, and relationships,	Students develop and use mathematical models, concepts, and procedures through horizontal and vertical mathematization.	Students relate mathematical results back to the original context and consider whether the results are reasonable in that situation.	Can support all three processes when contextual tasks require students to mathematize, calculate or

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	then represent the situation mathematically.			reason, and interpret their results.
Problem-Based Learning (PBL)	Students examine an authentic or ill-structured problem, identify what is known and unknown, and determine which aspects can be represented mathematically.	Students select and apply relevant concepts, facts, strategies, and procedures to investigate and solve the problem.	Students discuss, justify, and evaluate proposed solutions in relation to the initial problem and its contextual constraints.	Can support all three processes when the problem-solving sequence explicitly includes mathematical formulation and contextual evaluation, not only obtaining an answer.
Flipped Classroom	Not inherently addressed by the model. This process can be developed when pre-class materials or in-class tasks ask students to identify mathematical information and formulate contextual situations.	Classroom time can be used for guided practice, collaborative problem-solving, and applying mathematical concepts and procedures to contextual tasks.	Discussion, peer explanation, and teacher feedback can help students interpret results and evaluate their reasonableness in context.	Alignment is conditional on the learning tasks. The flipped format alone does not guarantee that the three PISA processes will be developed.
Integration	Context based	Students apply	Students interpret	Directly

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of PISA-Type Questions	items ask students to identify relevant information, recognize mathematical relationships, and formulate a mathematical representation of a real-world situation.	mathematical concepts, facts, and procedures, often through multi-step reasoning, to obtain a solution.	the solution in its original context, assess its reasonableness, and explain or evaluate the result.	aligned with the three processes when the selected items represent the PISA framework and are accompanied by discussion and feedback.
STEAM Approach	Interdisciplinary projects can ask students to define a real-world challenge, identify relevant variables, and formulate the mathematical aspects of the problem.	Students use mathematical concepts and procedures for example, measurement, geometry, proportional reasoning, or data analysis within design and investigation activities.	Students interpret data and mathematical results and evaluate whether a proposed design or solution meets the project's criteria and constraints.	Can support all three processes when mathematical reasoning is made explicit and central to the project; alignment may be limited if mathematics is only incidental.

Source: Authors' analysis based on the PISA 2022 mathematical literacy framework (OECD, 2023a).

As shown in Table 4, the five learning strategies have different potential contributions to the three mathematical literacy processes. Realistic Mathematics Education (RME/PMRI) and Problem-Based Learning (PBL) can engage students in formulating mathematical representations, applying relevant concepts and procedures, and interpreting solutions within contextual situations. The flipped classroom can provide opportunities for these processes through structured pre-class materials and guided classroom activities, although its alignment

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depends on the tasks designed by the teacher. Meanwhile, PISA-type questions have a direct conceptual alignment with the three processes because they are designed to assess students' ability to formulate, employ, and interpret mathematics in various contexts. The STEAM approach can also support these processes when mathematical reasoning is explicitly integrated into interdisciplinary activities. Overall, the analysis suggests that the development of mathematical literacy depends not only on the selection of a learning strategy but also on how learning activities are designed to engage students in all three processes.

Comparison of Effectiveness, Ease of Implementation, and Post-Pandemic Relevance

In addition to examining the alignment of learning strategies with the PISA mathematical literacy framework, it is important to consider the practical conditions required for their implementation. These considerations include the role of teachers, availability of learning resources, infrastructure requirements, and relevance to the Indonesian educational context. Table 5 presents a comparative analysis of the five learning strategies based on these implementation considerations. The comparison is intended to identify their respective strengths and limitations rather than establish a definitive ranking of their effectiveness.

Table 5. Comparison of Learning Strategies Based on Implementation Feasibility and Contextual Relevance

Learning strategy	Implementation considerations	Resource requirements	Potential relevance to the Indonesian context
RME/PMRI	Requires teachers to develop meaningful contextual problems and guide students through mathematical modeling.	Contextual learning materials, worksheets, and teacher preparation.	Can connect mathematical concepts with students' everyday experiences.
PISA-type questions	Can be integrated into regular mathematics lessons, provided that teachers select appropriate contextual tasks.	Validated question sets, assessment materials, and discussion activities.	Provides opportunities for students to become familiar with contextual and non-routine mathematical problems.
Problem-Based Learning	Requires careful problem selection, teacher facilitation, collaboration,	Contextual problem scenarios, worksheets, and	Can encourage reasoning, discussion, and problem-solving through real-world

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(PBL)	and sufficient learning time.	collaborative learning facilities.	situations.
STEAM approach	Requires coordination across subject areas and activities that make mathematical reasoning explicit.	Learning materials, project tools, and possible technological or laboratory facilities.	Can connect mathematics with science, technology, engineering, and art in interdisciplinary contexts.
Flipped classroom	Requires preparation of pre-class materials and structured activities during face-to-face learning.	Digital learning materials, devices, and internet access where online delivery is used.	Can provide more classroom time for discussion and contextual problem-solving, although access to digital resources may vary.

Source: Authors' comparative analysis based on the literature reviewed.

Table 5 highlights that each learning strategy has different implementation requirements and potential contributions to mathematical literacy development. The integration of PISA-type questions can be incorporated into regular mathematics lessons, while RME and PBL require teachers to design meaningful contextual problems and facilitate students' mathematical reasoning. The STEAM approach involves additional coordination across subject areas, whereas the flipped classroom depends partly on the availability of appropriate learning materials and digital infrastructure. These differences indicate that the selection of a learning strategy should consider not only its potential contribution to mathematical literacy but also the readiness of teachers, schools, and available learning resources.

DISCUSSION

Realistic Mathematics Education (RME) as the Foundation of Contextual Mathematical Literacy

Realistic Mathematics Education (RME), or Pendidikan Matematika Realistik Indonesia (PMRI), is conceptually aligned with the PISA mathematical literacy framework. Its principles, including the use of meaningful contexts, progressive mathematization, students' construction of knowledge, interactivity, and intertwinement, can provide opportunities to engage students in formulating situations mathematically, employing mathematical concepts and procedures, and interpreting results in context (OECD, 2023a).

Nusantara et al. (2021) developed PISA-like mathematics tasks using the COVID-19

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pandemic as a real-world context. Their study involved 27 secondary-level students and employed a design research approach to produce PISAComat tasks. The results indicated that the developed tasks met the validity and practicality criteria and had potential effects on students' mathematical literacy and life skills. This study demonstrates how familiar and relevant contexts can be incorporated into mathematical tasks to engage students in applying mathematical knowledge to real-world situations. However, these findings refer specifically to the developed PISAComat tasks and should not be generalized to all contextual learning strategies.

The implementation of RME requires teachers to select contexts that are meaningful to students and to guide the transition from informal strategies to more formal mathematical representations. Teacher preparation and the availability of appropriate learning materials are therefore important considerations. The studies reviewed here do not report teachers' difficulties in implementing RME directly, so this point still needs empirical support.

Problem-Based Learning (PBL) and the Development of Open-Ended Problem-Solving Skills

Problem-Based Learning (PBL) places an authentic or meaningful problem at the center of the learning process. In mathematics education, PBL can provide opportunities for students to identify relevant information, determine what is being asked, select mathematical concepts and procedures, and discuss the reasonableness of their solutions. These activities can be related to the three mathematical literacy processes in the PISA framework (OECD, 2023a).

The contribution of PBL to mathematical literacy depends on the quality of the problems and the way classroom activities are facilitated. Problems should require students to reason and make decisions rather than simply apply a predetermined procedure. Teachers also need to facilitate discussion and provide sufficient time for students to explore different solution strategies. Hasanah et al. (2026) examined PBL as a way to improve middle school students' mathematical literacy and took their early mathematical abilities into account, a reminder that students' starting points matter. In the PBL–PMRI math trail study (Fauziyah et al., 2023), students with high literacy met all six indicators while those with low literacy met only one, so literacy after the intervention still varied widely. Since that intervention combined PBL, PMRI, and a math trail, the results cannot be credited to PBL alone.

Flipped Classroom: Maximizing Face-to-Face Time for Higher-Order Thinking

The flipped classroom reorganizes the timing of content delivery and classroom activities. Students are introduced to learning materials before class, while face-to-face sessions can be

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used for guided practice, discussion, and contextual problem-solving. This arrangement may create more opportunities for students to explain their reasoning and apply mathematical concepts during classroom interaction.

However, the flipped classroom does not automatically develop mathematical literacy. Its contribution depends on the quality of pre-class materials and the design of classroom tasks. Implementation may also be affected by students' access to devices, internet connectivity, and their ability to study independently. None of the studies in Table 3 tests a flipped classroom on mathematical literacy. Patriana et al. (2021) describe asynchronous numeracy learning in elementary schools but did not examine a flipped design, so the potential of this strategy here rests on the alignment analysis in Table 4 and still needs empirical testing.

Integration of PISA-Style Questions: Direct and Most Feasible Strategy

The integration of PISA-type questions provides students with opportunities to work on contextual and non-routine problems. Such tasks can require students to identify relevant information, formulate mathematical representations, apply concepts and procedures, and interpret their results in the original context. When designed in accordance with the PISA framework, these questions can explicitly engage the processes of formulating, employing, and interpreting mathematics.

Syabaniah et al. (2025) used design research to develop context-based PISA-type questions on number content for Grade VIII students in Palembang. The question set was rated very valid (82.9%) and practical (80%), and student achievement was highest on formulating (80.8%), followed by employing (76.9%) and interpreting (70.6%). The authors concluded that the questions helped students understand contexts and develop strategies, while interpretation and justification still needed improvement. These conclusions come from descriptive results without a comparison group, so they show that the questions are usable rather than that they raise mathematical literacy. Familiarity with the PISA format is also not the same as the ability to reason, justify, and interpret results, and repeated exposure alone does not guarantee that ability. Munfarikhatin et al. (2022) add that most of the Indonesian literacy studies they reviewed for 2019–2021 used descriptive methods (52%).

The STEAM Approach: Fostering Interdisciplinary Understanding in Mathematical Literacy

The STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach connects mathematical concepts with interdisciplinary activities and real-world challenges. In this approach, mathematics may be used for measurement, geometry, proportional reasoning,

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data analysis, and the evaluation of design solutions. These activities can support mathematical literacy when students are required to explain the mathematical reasoning underlying their decisions.

The contribution of STEAM to mathematical literacy depends on whether mathematical thinking remains explicit and central to the learning activity. If mathematics is only incidental to a project, the activity may not sufficiently engage the mathematical processes emphasized in PISA. Implementation also requires suitable learning materials and coordination across subject areas. None of the studies reviewed here evaluates STEAM on mathematical literacy, so its contribution remains a conceptual possibility that future studies should test.

Implications for Efforts to Improve Indonesia's PISA Scores

The findings of this literature review indicate that contextual learning and problem-solving activities are important considerations in efforts to develop students' mathematical literacy. RME, PBL, the integration of PISA-type questions, the flipped classroom, and the STEAM approach offer different opportunities to engage students in applying mathematical concepts to real-world situations. However, their implementation requires consideration of teachers' competencies, learning objectives, available resources, and students' learning needs.

The PISA 2025 results show that Indonesia's mathematics performance remains below the OECD average, with a score of 364 compared with the OECD average of 463. This result was not statistically significantly different from Indonesia's 2022 score of 366, indicating that substantial challenges in mathematical literacy remain (OECD, 2026b). Mathematics instruction therefore needs to provide more opportunities for students to formulate mathematical problems, apply relevant concepts and procedures, and interpret mathematical results in various contexts.

No single learning strategy can be considered a universal solution for improving mathematical literacy. Teachers can select and combine strategies according to classroom conditions and learning objectives. The integration of PISA-type questions can provide contextual problem-solving experiences, while RME and PBL can support meaningful learning and mathematical reasoning. The flipped classroom and STEAM approach may also be considered when adequate resources and teacher preparation are available. These efforts should be accompanied by continuous assessment and professional development to support the improvement of mathematics learning.

CONCLUSION

This literature review indicates that Indonesian students' mathematical literacy

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performance remains below the OECD average, as reflected in the PISA 2025 results. The findings also highlight the importance of mathematics instruction that encourages students to formulate mathematical problems, employ mathematical concepts and procedures, and interpret mathematical results in real-world contexts.

The reviewed literature discusses several learning strategies that have the potential to support mathematical literacy development, including Realistic Mathematics Education (RME), Problem-Based Learning (PBL), the flipped classroom, the integration of PISA-type questions, and the STEAM approach. Each strategy offers different contributions and implementation requirements. Therefore, the selection and application of these strategies should consider learning objectives, teachers' competencies, students' needs, and the availability of educational resources.

Since this study is based on a literature review, its findings represent a synthesis of previous research rather than direct empirical evidence of the effectiveness of the strategies discussed. Further empirical studies are needed to examine their effectiveness across different educational contexts and student populations.

Suggestion

Mathematics teachers are encouraged to provide contextual learning activities that allow students to apply mathematical concepts in real-life situations. The integration of PISA-type questions, RME, and PBL can be considered according to classroom conditions and learning objectives. Schools and policymakers should also support teachers through professional development and the provision of appropriate learning resources. Future researchers are encouraged to conduct empirical studies to investigate the effectiveness of these strategies in improving students' mathematical literacy at different educational levels.

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