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Mathematical Reading Strategies as Predictors of Mathematical Literacy and Mathematical Problem-Solving Ability

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Abstract

This study aimed to examine whether mathematical reading strategies could predict students' mathematical literacy and mathematical problem-solving ability, both individually and simultaneously. The study employed a quantitative approach with an ex post facto design. The sample consisted of 31 eighth-grade students from a public junior high school in Gudo, Indonesia, selected through convenience sampling. Mathematical reading strategies were measured using a questionnaire integrating the Revised Metacognitive Awareness of Reading Strategies Inventory (MARSI-R) and Shepherd and van de Sande's mathematical reading framework. Mathematical literacy and problem-solving ability were measured using the same constructed-response task on systems of linear equations in two variables, with separate scoring rubrics. Data were analyzed using regression analyses and multivariate regression with Wilks' Lambda. The results showed that mathematical reading strategies significantly predicted mathematical literacy ($p < 0.001$) and problem-solving ability ($p < 0.001$). Simultaneously, mathematical reading strategies significantly predicted both outcomes ($p < 0.001$).

Keywords: mathematical reading strategies; mathematical literacy; mathematical problem-solving abilities; multivariate regression

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INTRODUCTION

Mathematics education in the 21st century requires students not only to master mathematical concepts and calculation procedures but also to be capable of using mathematics to understand, analyze, and solve problems across various contexts. These demands are closely linked to mathematical literacy and mathematical problem-solving skills. Mathematical literacy emphasizes an individual's ability to reason mathematically and to formulate, apply, and interpret mathematics in diverse real-life situations. Meanwhile, mathematical problem-solving skills require students to comprehend a problem, determine a solution strategy, execute that strategy, and evaluate the resulting outcome. Consequently, both abilities depend not only on mastery of mathematical concepts and procedures but also on students' capacity to comprehend the information contained in mathematical problems.

However, these skills remain a challenge for Indonesian students. The PISA 2022 results indicate that Indonesia's mathematics score was 366, compared with the OECD average of 472 (OECD, 2023). Beyond these performance metrics, research by Mayangsari et al. (2023) has found that students frequently make errors when interpreting mathematical representations in word problems. One of the significant obstacles students face in learning mathematics lies not in the calculation process itself but in their ability to comprehend mathematical texts. Previous findings show that students often make errors when solving word problems because they fail to comprehend the information, identify relationships among data, or interpret the mathematical representations presented in the problems. Students may even perform calculations correctly yet still fail to arrive at the correct solution because errors occur during the information-comprehension stage. These findings demonstrate that challenges in mathematics education are not solely related to calculation skills but also to the process by which students comprehend mathematical information. This aligns with classroom research conducted by Nurarini & Mariana (2024), which revealed that the majority of student errors in solving problems stemmed from a failure to comprehend the information provided.

The ability to comprehend information is closely linked to reading. Research conducted by Azhar et al. (2021) revealed that low reading proficiency is one of the primary obstacles to successful problem-solving. This suggests that when students are unable to grasp the meaning conveyed by a text, they tend to struggle to initiate the thinking process. Reading is fundamentally a complex process involving various aspects; it goes beyond merely vocalizing written words and encompasses visual activities, cognitive processes, psycholinguistic elements, and metacognition. Due to this complexity, developing effective reading skills often requires the application of appropriate strategies to ensure that the information presented is well understood (Dewi & Endarto, 2022). Reading strategies are essential techniques that students use to effectively recall, comprehend, and utilize information (Ghafournia, 2014). These strategies can be classified into several groups, one of which is metacognitive reading strategies. Mokhtari & Reichard, (2002) state that reading strategies provide mechanisms for self-regulation and awareness of one's cognitive processes during reading, both of which are crucial components in developing effective reading skills. Such metacognitive reading strategies are relevant not only to general reading activities but also to various fields of study, including mathematics. In mathematics education, this requirement becomes more complex because mathematical texts possess characteristics that distinguish them from ordinary texts. Mathematical texts tend to be dense, presenting information through a combination of words, symbols, notations, and various mathematical representations. Shepherd and van de Sande explain that reading in mathematics involves mathematical fluency, comprehension monitoring, and engagement. Thus, reading mathematics is not merely about understanding language but also about constructing meaning from symbols, notations, terms, and mathematical representations.

In this context, mathematical reading strategies cannot be viewed simply as general reading skills concerned solely with verbal language comprehension. Reading in mathematics is a process of constructing meaning from both language and various forms of mathematical representation. Tang et al. (2022) explain that mathematical texts possess unique characteristics; they utilize not only natural language but also symbols, notations, equations, images, diagrams, graphs, and mathematical vocabulary. Consequently, comprehending mathematical texts requires students to comprehend both verbal and symbolic information and interpret the relationships between them. These characteristics indicate that reading mathematics is a disciplinary reading practice distinct from general reading ability. Consequently, students require strategies specifically designed to comprehend, direct, monitor, and evaluate the process of reading mathematical texts. In this study, mathematical reading strategies are viewed as metacognitive strategies consciously employed during the reading process. The metacognitive reading strategies in MARSI-R (Mokhtari et al., 2018) provide a foundation for understanding how readers use strategies to regulate their cognitive processes during reading, while the framework proposed by Shepherd & van de Sande (2014) provides a more specific context for understanding the characteristics of reading in mathematics.

The MARSI-R metacognitive reading strategy framework establishes that readers employ strategies to regulate their cognitive processes during reading, while the framework proposed by Shepherd & van de Sande (2014) provides a specific framework for understanding the characteristics of reading in mathematics. In this study, these two frameworks are integrated, with MARSI-R serving as the foundational framework for identifying general reading strategies across three dimensions: Global Reading Strategy, Problem-Solving Strategy, and Supporting Reading Strategy (Mokhtari et al., 2018). These three dimensions are then combined with the mathematical reading aspects identified by Shepherd and van de Sande to characterize reading specifically within a mathematical context. This integration is operationalized by mapping each MARSI-R dimension onto the relevant mathematical reading aspects and translating them into operational indicators for instrument development. The definitions, similarities, differences, and operational indicators of each paired dimension are presented in the Methods section. Thus, the integration of the two frameworks uses the general reading strategy dimensions of the MARSI-R as the foundation and complements them with the mathematical reading aspects proposed by Shepherd and van de Sande to conceptualize mathematical reading strategies through activities that guide the initial reading process to understand the purpose, structure, and important information; monitor comprehension when difficulties are encountered; and use supporting strategies to understand mathematical symbols, terms, and information.

Theoretically, mathematical reading strategies are related to mathematical literacy and mathematical problem-solving ability. In the mathematical literacy process, students need to understand the context and information before formulating problems mathematically, applying appropriate mathematical concepts, and interpreting the results. Likewise, in problem solving according to Polya, the initial stage of understanding the problem provides the basis for students to determine and implement an appropriate solution strategy. Thus, reading strategies that help students identify information, monitor comprehension, and evaluate the meaning of texts have the potential to support the processes of mathematization and problem solving.

Previous studies have explored the relationship between reading ability and students' mathematical abilities, yet they differ in terms of the constructs, instruments, variables, and analytical approaches employed. Kusumastuti et al. (2025), for example, found a significant association between mathematical text reading ability and mathematical literacy. However, reading ability in that study was measured using a test that assessed students' demonstrated ability to read and understand mathematical texts. Thus, the measurement primarily captured reading performance as an outcome rather than the strategies or metacognitive processes students reported using while reading. Meanwhile, Kristiani & Tupulu (2025) showed that general reading ability contributed to problem-solving ability, but their study did not specifically examine mathematical reading strategies as a construct that considers the characteristics of mathematical information, such as mathematical terms, symbols, and representations. Other previous studies have also examined the association between mathematical literacy and mathematical problem-solving ability, but have not specifically positioned mathematical reading strategies as a predictor measured through students' awareness of how they approach, monitor, and support their reading of mathematical information. In contrast to these previous studies, the present study conceptualizes mathematical reading strategies as a metacognitive construct reflecting students' awareness and reported use of strategies when reading and comprehending mathematical information. The distinction between reading ability and reading strategies is therefore reflected in the measurement approach. A reading ability test assesses what students are able to demonstrate when they read and interpret mathematical information, whereas a questionnaire on reading strategies assesses the strategies that students report using to guide, monitor, and support their understanding during the reading process. Thus, the present study does not measure mathematical reading as a demonstrated reading performance, but focuses on students' awareness and reported use of strategies during mathematical reading.

The novelty of the present study lies not merely in combining two existing frameworks, but in integrating their complementary functions to operationalize mathematical reading strategies in a mathematics-specific context. The Revised Metacognitive Awareness of Reading Strategies Inventory (MARSI-R) was used as the primary framework for identifying students' metacognitive reading strategies through three dimensions: Global Reading Strategies (GRS), Problem-Solving Strategies (PSS), and Support Reading Strategies (SRS). These dimensions were then integrated with the mathematical reading aspects proposed by Shepherd and van de Sande (2014), namely mathematical fluency, comprehension monitoring strategies, and engagement with exposition. Specifically, GRS was integrated with mathematical fluency to capture strategies for guiding the overall reading process while attending to mathematical terms, symbols, and representations. PSS was integrated with comprehension monitoring to capture strategies for dealing with reading difficulties while monitoring whether mathematical information is understood correctly. SRS was integrated with engagement with exposition to capture the use of supporting strategies alongside students' active involvement in constructing an understanding of mathematical information. Through this integration, the MARSI-R provides the metacognitive structure of the construct, while Shepherd and van de Sande provide the mathematics-specific characteristics of the reading process. This integration therefore enables mathematical reading strategies to be operationalized not only in terms of general reading-strategy awareness but also in relation to the specific characteristics of mathematical information encountered by students. In terms of the analytical approach, regression analysis is used to examine the predictive role of mathematical reading strategies for each outcome individually, while multivariate analysis is used to examine their predictive role for both outcomes simultaneously.

This issue was also identified at one junior high school in Gudo, Indonesia, through initial informal communication with a mathematics teacher at the school. The communication was conducted to obtain general information about students' conditions and difficulties in learning mathematics, particularly when working with literacy-based mathematical problems. Based on the teacher's general description, students experienced difficulties in understanding the information presented in mathematical problems and in determining appropriate solutions. The identification of this issue was also supported by findings from previous studies related to students' difficulties in mathematical literacy and problem solving. Nurjanah & Saputra (2023) found that students' mathematical literacy ability in Sleman Regency was generally in the low category. In particular, students' performance in the formulate and employ processes was categorized as low, while their performance in the interpret process was categorized as very low. Similarly, Simbolon & Nurjanah (2024) found that students experienced difficulties in solving PISA-like

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mathematical literacy problems, particularly due to their limited familiarity with mathematical literacy tasks and the lack of contextual learning in classroom instruction. These findings indicate that students may experience difficulties not only in applying mathematical concepts but also in understanding and interpreting information presented in contextual mathematical problems. In addition to difficulties in mathematical literacy, previous studies have also reported low mathematical problem-solving abilities among junior high school students. Gunawan et al. (2023) found that students' mathematical problem-solving abilities were low, with an average score of 22.28 and a success rate of only 15.23%. This finding indicates that students also continue to experience difficulties in solving mathematical problems. The teacher's role in the learning process, along with the effective use of instructional media, is expected to contribute to improving students' mathematical problem-solving abilities. This finding is also consistent with the study conducted by Rahayu et al. (2023), which found that junior high school students experienced difficulties across all stages of Polya's problem-solving process, including understanding the problem, devising a plan, carrying out the plan, and looking back. The difficulties included identifying the given and required information, constructing mathematical models, performing calculations accurately, and checking solutions. These findings indicate that students still experience difficulties throughout the mathematical problem-solving process.

However, no formal interview, systematic classroom observation, or preliminary assessment was conducted to obtain direct evidence of students' mathematical literacy and problem-solving ability. Therefore, the information obtained from the teacher was used as preliminary contextual information rather than as formal assessment data. This limitation should be considered when interpreting the initial identification of the research problem. The preliminary information, together with findings from previous studies, provided a basis for examining mathematical reading strategies as a predictor of students' mathematical literacy and mathematical problem-solving ability. Therefore, this study aims to determine whether mathematical reading strategies can predict students' mathematical literacy and mathematical problem-solving ability, both individually and simultaneously.

METHODS

This study employed a quantitative approach with an *ex post facto* research design to examine whether mathematical reading strategies predict students' mathematical literacy and mathematical problem-solving ability. The *ex post facto* design was selected because the variables were measured as they naturally occurred, without manipulation or experimental treatment by the researcher. Regression analysis was used to examine the predictive role of mathematical reading strategies in students' mathematical literacy and mathematical problem-solving ability, both individually and simultaneously.

The study population consisted of 285 eighth-grade students at a public junior high school in Gudo, Indonesia. All eighth-grade classes had relatively similar learning characteristics and were not differentiated based on students' academic ability levels. Thus, there was no grouping of classes according to high, medium, or low academic ability. This condition allowed each eighth-grade class to be considered a unit with relatively comparable population characteristics during the sampling process.

At the initial stage, the sampling procedure was planned to use *cluster random sampling*, with the class serving as the sampling unit. Among the available eighth-grade classes, random selection was conducted to determine the class to be used as the sample cluster. Based on the random selection, one class was selected as the cluster. However, when the study was about to be conducted, the number of students who were able to participate from the selected class was insufficient because some students were absent. To ensure that a sufficient number of participants could take part in the entire research process, class VIII-A, which consisted of 31 students, was subsequently selected as the research sample based on student availability. The use of *convenience sampling* in this study constitutes one of its limitations because the final sample was not randomly selected from all classes in the population. The independent variable in this study was mathematical reading strategies, while the dependent variables were mathematical literacy and mathematical problem-solving ability. Mathematical reading strategies were measured using a questionnaire developed by integrating the *Revised Metacognitive Awareness of Reading Strategies Inventory* (MARSI-R) with the mathematical reading framework proposed by Shepherd and van de Sande (2014). The MARSI-R is a self-report instrument designed to measure students' metacognitive awareness of reading strategies and their perceptions of using such strategies when reading academic texts. The MARSI-R consists of 15 items covering three dimensions: *Global Reading Strategies* (GRS), *Problem-Solving Strategies* (PSS), and *Support Reading Strategies* (SRS).

Meanwhile, Shepherd and van de Sande (2014) identified characteristics of mathematical readers through three aspects: *mathematical fluency*, *comprehension monitoring strategies*, and *engagement with exposition*. *Mathematical fluency* refers to readers' fluency in understanding mathematical terms and symbols and connecting symbolic configurations with their meanings. *Comprehension monitoring* refers to readers' awareness of monitoring and checking their understanding of the material being read, whereas *engagement with exposition* refers to readers' active involvement in developing a deeper understanding when encountering new or difficult mathematical information.

Table 1. Definitions of the MARSI-R Dimensions and Mathematical Reading Aspects

Source	Dimension/Aspects	Description
MARSI-R	Global Reading Strategies (GRS)	Strategies used before and during reading to gain an overall underst
	Problem-Solving Strategies (PSS)	Strategies used when experiencing difficulties in understanding the
	Support Reading Strategies (SRS)	Supporting strategies used to facilitate text comprehension.
Shepherd and van de Sande	Mathematical Fluency	Focuses on readers' ability to fluently understand mathematical syr
	Comprehension Monitoring Strategies	Focuses on readers' ability to monitor and evaluate their understanc
	Engagement	Focuses on readers' active engagement in understanding the text, su seeking additional resources.

Based on these characteristics, the two frameworks have different but complementary focuses. The MARSI-R provides a general framework for metacognitive strategies used by readers to guide, regulate, and support the reading process**,** whereas Shepherd and van de Sande provide more specific characteristics of reading processes in the context of mathematics. Thus, the MARSI-R describes the dimensions of reading strategies from a metacognitive perspective, while the framework proposed by Shepherd and van de Sande provides specificity regarding the characteristics of mathematical information and how readers interact with such information.

Based on these similarities in function and conceptual relevance, *Global Reading Strategies* (GRS) were integrated with *mathematical fluency*. GRS function to guide and prepare readers for the overall reading process, whereas *mathematical fluency* provides specificity regarding what needs to be understood when reading mathematics, particularly mathematical terms, symbols, and representations. Thus, integrating the two enables global reading strategies to be considered within the context of mathematical information.

Problem-Solving Strategies (PSS) were integrated with *comprehension monitoring strategies*. Both involve the use of strategies to address difficulties in comprehension. However, PSS in the MARSI-R refers to reading strategies used when readers encounter difficulties, whereas *comprehension monitoring* more specifically emphasizes readers' awareness of checking and regulating their understanding of mathematical texts. Therefore, *comprehension monitoring* was incorporated to provide a mathematical reading context for problem-solving strategies. Meanwhile, *Support Reading Strategies* (SRS) were integrated with *engagement with exposition*. SRS provide various means or actions that support the reading process, whereas *engagement with exposition* emphasizes readers' active and in-depth involvement in constructing understanding. Both contribute to sustaining the process of understanding information, but they differ in their primary focus. SRS emphasize the strategies or tools used to support comprehension**,** whereas *engagement with exposition* emphasizes the extent to which readers are actively involved in constructing understanding**.**

Thus, the integration of the two frameworks was not intended to suggest that each MARSI-R dimension and mathematical reading aspect has an identical meaning. Rather, the integration was conducted by retaining the fundamental function of each MARSI-R dimension as a framework for reading strategies, while providing a mathematical reading context and specific characteristics through the relevant aspects proposed by Shepherd & van de Sande (2014). The mathematical reading strategies questionnaire was developed by adapting the MARSI-R framework and integrating it with the mathematical reading aspects proposed by Shepherd and van de Sande. The MARSI-R served as the primary framework for identifying students' metacognitive reading strategies through three dimensions: Global Reading Strategies, Problem-Solving Strategies, and Support Reading Strategies. The items were translated into Indonesian and adjusted to the context of reading mathematical information. The relevant mathematical reading aspects proposed by Shepherd and van de Sande were then integrated into the corresponding MARSI-R dimensions. The integrated dimensions were subsequently translated into operational indicators and questionnaire statements. The final questionnaire consisted of 15 items, with five items representing each integrated dimension. The questionnaire instrument was validated by two validators, a mathematics education lecturer with expertise in the development and evaluation of educational instruments and a junior high school mathematics teacher with experience in mathematics instruction. Both validators assessed the alignment of the questionnaire items with the dimensions and indicators of mathematical reading strategies, the clarity of the statements, and the appropriateness of the language and level of comprehension for junior high school students. The items were evaluated using a four-point scale, ranging from 1 (not appropriate), 2 (less appropriate), 3 (sufficiently appropriate), to 4 (appropriate). Differences in the ratings provided by the two validators were considered by comparing their assessments of each aspect and examining the comments and suggestions accompanying the ratings. When differences in ratings or specific comments regarding an item were identified, revisions were made by considering the feedback from both validators and aligning the revisions with the measurement objectives and the characteristics of junior high school students. Thus, the validation results were considered not only based on the numerical ratings but also on the qualitative feedback provided by the two validators. The questionnaire was subsequently revised based on this feedback before being used in the study. No formal inter-rater reliability test was conducted to assess the consistency between the ratings provided by the two validators. Therefore, the absence of an inter-rater reliability analysis is acknowledged as one of the limitations of the instrument validation process. Nevertheless, the questionnaire was revised based on the comments and suggestions provided by both validators before being used in the study. The resulting mapping is presented in table 2.

Table 2. Integration of the MARSI-R Dimensions and the Shepherd and van de Sande Framework

Dimension Integrade	Forms of Mathematical Reading Strategies	Numbers	Representative Statement
Global Reading Strategies + Mathematical fluency	Strategies for guiding the initial reading process to identify the purpose, structure, and key information in a problem.	1 - 5	I read mathematical problems with the purpose of understanding what needs to be done before starting to solve them. I look at the overall problem to identify what is being asked before reading further. I check whether the information in the problem is relevant to what I need to solve the problem. I can easily recognize symbols, terms, or emphasized information in the problem to identify important information. I assess whether the information in the problem is sufficient to be used in solving the problem.
Problem Solving Strategies + Comprehension monitoring	Strategies for monitoring comprehension when encountering difficulties and evaluating understanding throughout the reading process.	6 - 10	I reread the mathematical problem when I feel that I have not understood it well. I recognize when my solution steps do not correspond to the problem. I check the steps of my mathematical problem-solving process. I change my solution approach when the result does not match the conditions stated in the problem. I slow down my problem-solving process when I encounter difficulties.

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Dimension Integrade	Forms of Mathematical Reading Strategies	Numbers	Representative Statement
Support Reading Strategies + Engagement	Supporting strategies and active engagement in comprehending mathematical symbols, terms, and information through specific methods that facilitate understanding of mathematical problems.	11 - 15	I note down important information from the mathematical problem to help me understand its content. I read the mathematical problem aloud in a soft voice to help me understand its content. I actively try to understand the meanings of mathematical symbols or terms in the problem. I mark important parts of the problem to help me focus on understanding the information. I continue trying to understand the problem even when it seems difficult by using methods that I find helpful.

Based on the integration of these elements, 15 statement items were formulated, with five items for each aspect. The questionnaire and test instruments were reviewed by two validators, namely a mathematics education lecturer with expertise in the development and evaluation of educational instruments and a junior high school mathematics teacher with teaching experience at the junior high school level. The validation was conducted using a four-point rating scale: 1 = not appropriate, 2 = less appropriate, 3 = moderately appropriate, and 4 = appropriate. For the questionnaire, the validation focused on the suitability of the items with the dimensions and indicators of mathematical reading strategies, as well as the clarity and appropriateness of the statements for junior high school students. The validators also provided comments and suggestions for item revisions, which were considered in the finalization of the questionnaire. This validation was limited to expert and practitioner review; no empirical validity testing, item analysis, or statistical reliability testing was conducted. Therefore, the instrument's validity evidence in this study is based on expert and practitioner judgment, while the absence of empirical validity and reliability testing is acknowledged as a limitation of the study. The items were designed to describe the strategies students employ when reading and comprehending mathematical problems. The instrument uses a five-point Likert scale: 1 = never, 2 = rarely, 3 = sometimes, 4 = often, and 5 = always. The mathematical reading strategy score is calculated by summing the scores across all items, with higher scores indicating a greater use of mathematical reading strategies. The instruments used to measure mathematical literacy and mathematical problem-solving ability consisted of a single constructed-response task in the form of a contextual problem based on the Grade VIII topic of Systems of Linear Equations in Two Variables (SPLDV). The same task was used to obtain data for both variables; however, students' responses were analyzed using two different scoring rubrics according to the respective constructs being measured. Mathematical literacy was analyzed based on the mathematical literacy processes in the PISA framework, namely formulating, employing, and interpreting. Meanwhile, mathematical problem-solving ability was analyzed based on Polya's problem-solving stages, namely understanding the problem, devising a plan, carrying out the plan, and looking back.

Although both variables were measured using responses to the same task, the constructs were differentiated through the use of distinct indicators and scoring rubrics. For mathematical literacy, scoring focused on students' ability to formulate, employ, and interpret mathematics in the context of the given problem. Meanwhile, for mathematical problem-solving ability, scoring focused on the problem-solving process based on Polya's stages. Thus, the same response was used as the data source, but each construct was assessed based on its respective conceptual framework and scoring criteria.

The measurement of mathematical literacy and mathematical problem-solving ability in this study used students' responses to the same constructed-response task. Although the two constructs were differentiated conceptually and operationally through distinct indicators and scoring rubrics, the use of a single task may result in an overlap in the responses used to obtain the two scores. This overlap may make the relationship between mathematical literacy and mathematical problem-solving ability appear stronger than it actually is. This condition represents a measurement limitation that should be considered when interpreting the research findings. Future research is recommended to use multiple tasks for each construct so that the measurement of mathematical literacy and mathematical problem-solving ability can be more clearly differentiated.

The following table presents the instrument blueprint for the mathematical literacy variable, categorized according to the mathematical literacy processes of formulate, employ, and interpret. The mathematical literacy processes in this study were adopted from the PISA framework and operationalized through three processes: formulate, employ, and interpret. The selection of these three processes was based on the structure of the assessment task and the characteristics of the system of linear equations in two variables content used in this study. The assessment task required students to formulate mathematical information from the given context (formulate), apply appropriate mathematical concepts and procedures to solve the problem (employ), and interpret the resulting solution and relate it back to the context of the problem (interpret). Although the PISA 2022 framework also includes the evaluating process, it was not operationalized separately in this study because it was not explicitly required as a distinct demand in the assessment task. This decision is supported by OECD (2023), which states that "*it is often not necessary to engage in every stage of the modelling cycle, especially in the context of an assessment*." This statement indicates that, in the context of assessment, a task does not necessarily need to involve all stages of the mathematical modelling cycle. Therefore, the decision not to operationalize evaluating as a separate process in this study was based on the alignment between the demands of the assessment task, the characteristics of the mathematical content, and the principle of operationalizing mathematical literacy processes in an assessment context. Accordingly, the formulate, employ, and interpret processes were considered the most appropriate for the demands of the assessment task and the mathematical content examined in this study.

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Table 3. Mathematical Literacy Instrument Grid

Mathematical Literacy	Indicator	Item
Formulate	Identifying the mathematical elements contained in real-life problems by determining the relevant variables and translating the problems into mathematical form.	1
Employ	Designing and applying appropriate mathematical models to obtain mathematical solutions.	
Interpret	Interpreting the results and evaluating their appropriateness in relation to the context of the real-world problem.	

The assessment of mathematical literacy is based on the scoring guidelines from the mathematical literacy scoring rubric. The table below presents the mathematical literacy scoring rubric.

Table 4. Mathematical literacy scoring rubric

Proses Literasi Matematis	Criteria	Score
Formulate	Unable to identify the mathematical elements or determine the relevant variables and unable to translate the problem into a mathematical model.	0
	Able to identify some relevant mathematical elements and variables, but the identification is incomplete. The mathematical model created is also inaccurate or incomplete.	1
	Able to identify the mathematical elements and determine the relevant variables, but the mathematical model created is still incomplete or contains minor errors.	2
	Able to correctly identify all mathematical elements in a real-life problem, determine the relevant variables completely, and translate the problem into an appropriate mathematical model (e.g., equations, variables, diagrams, or pictures).	3
Employ	Unable to apply the mathematical model that has been developed or does not show the solution process.	0
	Attempts to apply the mathematical model, but the solution steps are incorrect or the procedure used is inappropriate, resulting in an incorrect solution.	1
	Able to apply the mathematical model to solve the problem, but makes minor procedural or calculation errors, resulting in an incorrect solution.	2
	Able to correctly apply the mathematical model and carry out the solution steps appropriately to obtain the correct solution.	3
Interpret	The student is unable to interpret the result obtained or provides an interpretation that is unrelated to the	0

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Proses Literasi Matematis	Criteria	Score
	context of the problem.	
	The student is able to provide an interpretation of the result obtained, but the interpretation is inaccurate or inconsistent with the context of the problem.	1
	The student is able to provide an interpretation that is relevant to the context of the problem, but the interpretation is incomplete or contains some errors in explaining the meaning of the result obtained.	2
	The student is able to provide a correct, complete, and contextually appropriate interpretation and accurately explain the meaning of the mathematical result.	3

Meanwhile, mathematical problem-solving ability was measured based on Polya (1945) four stages: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. The following table presents the instrument grid for the mathematical problem-solving ability variable.

Table 5. Mathematical Problem-Solving Ability Instrument Grid

Polya's Stages	Indicators	Item
Understanding the Problem	Students are able to identify and write down the given information and what is being asked	
Devising a Plan	Students are able to develop an appropriate solution strategy and formulate the problem correctly	1
Carrying Out the Plan	Students are able to implement the solution strategy according to the plan that has been developed	
Looking Back	Students are able to check the obtained results against what is being asked and draw a conclusion consistent with the context of the problem.	

Then, the assessment of mathematical problem-solving ability was based on the scoring guidelines provided in the mathematical problem-solving ability rubric. The scoring rubric is presented in the table below.

Table 6. Mathematical Problem-Solving Ability Scoring Rubric

Polya's Stages	Criteria	Score
Understanding the Problem	The student does not identify or write down the given information and what is being asked in the problem.	0
	The student identifies and writes down the given information and what is being asked in the problem, but does so incorrectly.	1
	The student identifies and writes down the given information and what is being asked in the problem, but the information is incomplete.	2

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Polya's Stages	Criteria	Score
	The student correctly and completely identifies and writes down the given information and what is being asked in the problem.	3
Devising a Plan	The student does not write or construct a mathematical model and does not state the formula to be used.	0
	The student writes or constructs a mathematical model and states the formula to be used, but both are incorrect.	1
	The student writes or constructs a mathematical model correctly but states the formula incorrectly.	2
	The student writes or constructs a mathematical model and states the formula correctly, but the response is incomplete.	3
	The student writes or constructs a mathematical model and states the formula completely and correctly.	4
Carrying Out the Plan	The student does not carry out the solution process.	0
	The student carries out the solution according to the plan, but the solution steps and calculations are incorrect.	1
	The student carries out the solution according to the plan, but the solution steps are incorrect while the calculations are correct.	2
	The student carries out the solution according to the plan, with correct solution steps but incorrect calculations.	3
	The student carries out the solution according to the plan, with correct and complete solution steps and calculations.	4
Looking Back	The student does not check the result obtained and does not provide a conclusion that is appropriate to the context of the problem.	0
	The student checks the result obtained and/or provides a conclusion, but the checking and conclusion are inaccurate and do not correspond to the context of the problem.	1
	The student correctly checks the result obtained or provides a correct conclusion, but does not perform both aspects completely.	2
	The student correctly checks the result obtained and provides a conclusion that is appropriate to the context of the problem, but one of the two aspects is still incomplete or less accurate.	3
	The student correctly and completely checks the result obtained and provides a correct, complete, and contextually appropriate conclusion.	4

The total score for each variable, namely mathematical literacy and mathematical problem-solving ability, was calculated as follows:

$$Final\ score = \frac{Total\ score\ obtained}{Maximum\ possible\ score} \times 100$$

The questionnaire and test instruments were validated by two validators, namely a mathematics education lecturer with expertise in the development and evaluation of educational instruments and a junior high school mathematics teacher with teaching experience at the junior high school level. The validation was conducted using a four-point rating scale: 1 = not appropriate, 2 = less appropriate, 3 = moderately appropriate, and 4 = appropriate. For the questionnaire, the validation covered the suitability of the items with the dimensions and indicators of mathematical reading strategies, as well as the clarity and appropriateness of the statements. For the test instrument, the validation covered the alignment of the tasks with the indicators of mathematical literacy and mathematical problem-solving ability, the suitability of the tasks with the topic of Systems of Linear Equations in Two Variables (SPLDV), and the clarity of the tasks and scoring rubrics.

The validation results for both the questionnaire and test instruments were analyzed using the percentage of the mean validation score, adapted from (Syafrudin & Sujarwo, 2019).

Table 7. Validity Criteria (Syafrudin & Sujarwo, 2019)

Percentage	Criteria	Description
$76\% \leq S_v \leq 100\%$	Valid	No revision required
$50\% \leq S_v < 76\%$	Sufficiently valid	Minor revision
$26\% \leq S_v < 50\%$	Less valid	Major revision
$0\% \leq S_v < 26\%$	Invalid	Not acceptable

The percentage was calculated by comparing the mean score obtained from each validator with the maximum possible score. The questionnaire validation results showed a percentage of 62.8% from Validator 1 and 74.2% from Validator 2, with a mean percentage of 68.5%. The differences in the validators' ratings were addressed by considering the comments and suggestions provided by both validators when revising the questionnaire items. No formal inter-rater reliability test was conducted to assess the consistency between the two validators' ratings. Therefore, the absence of an inter-rater reliability analysis is acknowledged as a limitation of the instrument validation process. Based on the validity criteria, this result was categorized as sufficiently valid. Meanwhile, the test instrument validation results showed a percentage of 84.09% from Validator 1 and 88.63% from Validator 2, with a mean percentage of 86.36%. This result was categorized as valid. The instruments were subsequently revised based on the validators' suggestions and feedback before being used in the study. After the data were processed, they were analyzed using descriptive statistics and multivariate regression analysis. The prerequisite tests included normality, linearity, and heteroscedasticity tests. Normality was assessed using the Kolmogorov–Smirnov test. The regression standardized residuals were also examined visually using histograms and Normal P–P Plots to provide additional evidence regarding their distribution. The independence of the observations was maintained through the data collection procedure, in which each student completed the questionnaire and test independently. No formal outlier analysis, inter-variable correlation test between the dependent variables, and Shapiro–Wilk test. These aspects are acknowledged as limitations of the analysis and should be considered when interpreting the research findings. Partial effects were examined for each dependent variable, while the simultaneous effect was analyzed using the multivariate Wilks' Lambda statistic. The significance level was set at 0.05.

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RESULTS AND DISCUSSION

Before conducting the assumption tests and hypothesis analyses, descriptive statistics were first presented to provide an overview of the characteristics of the study data. The descriptive statistics included the number of observations (N), mean, standard deviation, minimum, and maximum values for mathematical reading strategies, mathematical literacy, and mathematical problem-solving ability. The descriptive statistics for the three variables are presented in table below.

Table 8. Descriptive Statistics of the Study Variables

Variabel	N	Mean	Standart Deviation	Minimum	Maximum
Mathematical Reading Strategies	31	4	6,67	25	65
Mathematical Literacy	31	44,45	11,11	11,11	77,75
Mathematical Problem-Solving Ability	31	46,67	11,11	13,33	80

Furthermore, prerequisite tests were conducted, including tests of normality, linearity, and heteroscedasticity. Data normality was assessed using the Kolmogorov–Smirnov test. The independence of observations was maintained through the data collection procedures, in which each student completed the questionnaire and tests independently. However, formal outlier screening and examination of the relationships between the dependent variables were not conducted. Therefore, these aspects should be considered as limitations when interpreting the results of the multivariate regression analysis. The results of the prerequisite tests indicated that the data met the assumptions examined for the regression analysis. The normality test was conducted to determine whether the residuals in the regression models followed a normal distribution. Based on the Kolmogorov–Smirnov test, a significance value of 0.200 was obtained for the mathematical literacy model and 0.200 for the mathematical problem-solving ability model. The Kolmogorov–Smirnov test was used to assess the normality of the regression residuals as specified in the statistical analysis procedures of this study. Although the sample size was relatively small (n = 31), for which the Shapiro–Wilk test is generally considered more appropriate, this study used the Kolmogorov–Smirnov test. The use of the Kolmogorov–Smirnov test with this sample size is acknowledged as one of the limitations of the normality assessment in this study. Therefore, the assessment of normality was not based solely on the significance value of the Kolmogorov–Smirnov test; visual examination of the distribution of standardized regression residuals was also conducted using histograms and Normal P–P Plots. Since both Kolmogorov–Smirnov significance values were greater than 0.05, there was no evidence that the residuals in either model significantly deviated from a normal distribution. The visual examination also showed that the residuals generally followed a pattern close to a normal distribution. Thus, the normality assumption was considered satisfied based on both the statistical test and visual examination. The normality plots for the mathematical literacy model and the mathematical problem-solving ability model are presented below. The following is the normality test graph for X and Y1.

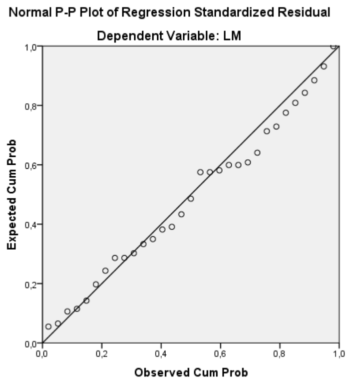

Figure 1. Graphical Results of the Normality Test for X and Y1

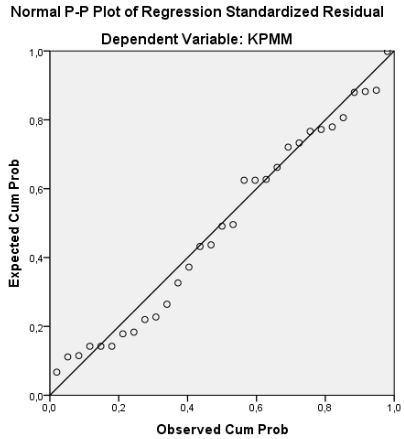

Figure 2. Graphical Results of the Normality Test for X and Y2

Next, a linearity test was performed to determine whether the relationships between the predictor variable, mathematical reading strategies, and each dependent variable were linear. The linearity test yielded significance values of 0.340 for the relationship with mathematical literacy and 0.906 for the relationship with mathematical problem-solving ability. As both values were greater than 0.05, the relationships between the predictor variable and the respective dependent variables were considered linear. Meanwhile, a heteroscedasticity test was conducted to examine whether the residual variances in the regression models were unequal. The Glejser test produced significance values of 0.754 for the mathematical literacy model and 0.586 for the mathematical problem-solving ability model. Both values exceeded 0.05, indicating no evidence of heteroscedasticity. Thus, the data met the prerequisite assumptions for regression analysis, allowing further analysis of the predictive role of mathematical reading strategies in mathematical literacy and mathematical problem-solving ability.

Table 9. Partial Regression Test Result

Source	Dependent Variable	B	SE	t	df	Sig.	confidence interval	R^2	Adjusted R^2
MM	LM	1,548	0,194	7,972	29	,001	1,151 - 1,945	0,687	0,676
	KPMM	1,650	0,184	8,948	29	,001	1,274 - 2,026	0,736	0,727

The regression analysis showed that mathematical reading strategies were statistically significant in predicting students' mathematical literacy, with a significance value of 0.001 < 0.05. The regression model yielded an R^2 of 0.687 and an adjusted R^2 of 0.676, indicating that, within the study sample, the regression model accounted for approximately 67.6% of the variance in mathematical literacy after adjustment for the number of predictors. This value represents the proportion of variation in mathematical literacy that could be accounted for by the regression model in the present data and should not be interpreted as evidence of a causal effect of mathematical reading strategies on mathematical literacy. This finding indicates an association between mathematical reading strategies and the process of understanding mathematical information presented in various forms, such as text, symbols, terms, and mathematical representations. This is supported by Ully & Hakim (2022), who showed that, in the process of formulating a problem, students need to understand the text or information contained in the problem before translating it into mathematical form. Thus, the ability to understand mathematical information can be regarded as one aspect that supports the process of mathematical literacy, particularly in identifying and formulating information from a problem into mathematical form (Muslimah & Pujiastuti, 2020). The findings of this study are also consistent with those of Kusumastuti et al. (2025), who found an association between mathematical reading ability and students' mathematical literacy. Their study used Pearson correlation analysis and obtained a correlation coefficient of 0.946 with a significance value of p = 0.000 < 0.05. These findings support the association between mathematical reading ability and mathematical literacy, although Kusumastuti et al. (2025) examined the relationship between the variables, whereas the present study used regression analysis to examine the predictive relationship between mathematical reading strategies and mathematical literacy. Meanwhile, the analysis indicated that mathematical reading strategies were also statistically significant in predicting students' mathematical problem-solving ability. This was demonstrated by a significance value of 0.001 < 0.05. Thus, it can be concluded that mathematical reading strategies were statistically significant in predicting students' mathematical problem-solving ability. The adjusted R Squared of 0.727 indicates that, within the study sample, the model explained approximately 72.7% of the variance in mathematical problem-solving ability scores.Students who are able to understand the information contained in problems may find it easier to identify what is known and what is being asked, select appropriate mathematical concepts, and develop a systematic solution strategy. Conversely, difficulties in comprehending the problem may lead to errors at the initial stage, which can subsequently affect the later stages of the problem-solving process. Students' inability to understand the context of a problem tends to result in errors in subsequent solution processes (Putri & Purwanto, 2022). The most dominant difficulties have been found in understanding the content of problems and identifying the information that is given and what is being asked (Putri & Jupriyanto, 2026).

These findings are consistent with the research of Kristiani & Tupulu (2025), which showed a significance value of 0.002 < 0.05, indicating that reading ability and learning motivation had a significant partial effect on students' problem-solving ability.

Table 10. Results of the Simultaneous Test

	Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	,346	7,410[b]	2,000	28,000	,003	,346
	Wilks' Lambda	,654	7,410[b]	2,000	28,000	,003	,346
	Hotelling's Trace	,529	7,410[b]	2,000	28,000	,003	,346
	Roy's Largest Root	,529	7,410[b]	2,000	28,000	,003	,346
MM	Pillai's Trace	,748	41,553[b]	2,000	28,000	,000	,748
	Wilks' Lambda	,252	41,553[b]	2,000	28,000	,000	,748
	Hotelling's Trace	2,968	41,553[b]	2,000	28,000	,000	,748
	Roy's Largest Root	2,968	41,553[b]	2,000	28,000	,000	,748

Based on the output table above, the results of the multivariate regression analysis using Wilks' Lambda showed a simultaneous significance value of 0.000. Since 0.000 < 0.05, these results indicate that mathematical reading strategies were statistically significant in predicting students' mathematical literacy and mathematical problem-solving ability simultaneously.

The regression results showed that mathematical reading strategies were statistically significant in predicting students' mathematical literacy and mathematical problem-solving ability. For mathematical literacy, the regression model yielded an R^2 of 0.687 and an adjusted R^2 of 0.676, indicating that the model accounted for approximately 67.6% of the variance in mathematical literacy within the study sample after adjustment. For mathematical problem-solving ability, the model yielded an R^2 of 0.736 and an adjusted R^2 of 0.727, indicating that the model accounted for approximately 72.7% of the variance in problem-solving ability after adjustment. In the simultaneous analysis, the Wilks' Lambda test was statistically significant ($p < 0.001$), indicating that mathematical reading strategies significantly predicted the two outcomes jointly. These findings suggest that mathematical reading strategies play an important role in supporting students' mathematical literacy and problem-solving ability. Mathematical reading strategies were developed by integrating the reading strategies from MARSI-R with the mathematics-specific reading approaches proposed by Shepherd and van de Sande. These strategies encompass guiding the initial reading process to understand mathematical contexts, monitoring comprehension when encountering difficulties, and employing supporting strategies to interpret mathematical symbols, terms, and representations.

Research by Kusumastuti et al. (2025) demonstrates a relationship between mathematical reading ability and students' mathematical literacy. Specifically, the study reported a very strong and significant correlation between the ability to read mathematical texts and mathematical literacy, with a Pearson correlation coefficient of 0.946 and a significance level of $p < 0.001$. The findings of this study can be explained through the relationship between mathematical reading strategies and the mathematical literacy processes within the PISA framework, namely formulate, employ, and interpret. At the formulate stage, mathematical reading strategies help students understand the context of the problem, identify the given and required information, and determine relevant information to formulate into a mathematical form. At the employ stage, understanding mathematical terms, symbols, and representations, along with monitoring comprehension, helps students select and apply appropriate mathematical concepts, procedures, or strategies. Subsequently, at the interpret stage, rereading, monitoring comprehension, and reviewing information help students interpret mathematical results and relate them back to the context of the problem. Thus, mathematical reading strategies can support the mathematical literacy process from understanding and formulating problems, applying mathematical concepts, to interpreting results within the context.

Furthermore, a study by Kristiani & Tupulu (2025) reported a significance value of 0.002 (< 0.05), indicating that reading ability and learning motivation had a significant simultaneous effect on students' problem-solving ability. The findings regarding mathematical problem-solving ability can also be explained through Polya's problem-solving stages, namely understanding the problem, devising a plan, carrying out the plan, and looking back. At the stage of understanding the problem, mathematical reading strategies help students identify the given information, the required information, and the relationships among the information presented in the problem. At the stage of devising a plan, understanding the information and monitoring comprehension help students determine appropriate mathematical concepts or strategies for solving the problem. At the stage of carrying out the plan, reading strategies accompanied by comprehension monitoring help students ensure that the solution steps remain consistent with the information and conditions presented in the problem. At the stage of looking back, students can reread the problem and evaluate whether the obtained result is consistent with the question and the context of the problem. Thus, mathematical reading strategies can support the problem-solving process at each of Polya's stages through understanding, monitoring, and evaluating information throughout the solution process.

Based on these findings, it can be concluded that mathematical reading strategies were statistically significant in predicting the mathematical literacy and mathematical problem-solving ability of students at SMP Negeri 1 Gudo. This study has several limitations that should be considered when interpreting the findings. First, the study involved 31 students from one class at a public junior high school in Gudo; therefore, generalization of the findings to the broader junior high school student population should be made with caution. Second, the study employed an ex post facto design; therefore, the regression analysis indicates statistical predictive ability and cannot be used to establish a causal relationship. Third, mathematical reading strategies were measured using a questionnaire, meaning that the data obtained depended on the responses provided by the students. Fourth, mathematical literacy and mathematical problem-solving ability were measured using the same single constructed-response task based on the topic of a system of linear equations in two variables, although the two variables were analyzed using different indicators and scoring rubrics. The use of the same task may result in overlap in the responses and criteria used to measure the two variables, which may affect the strength of the observed predictive relationships. In addition, because the measurements were conducted using the topic of a system of linear equations in two variables, the findings may not necessarily represent students' abilities in other areas of mathematics. Therefore, future research could involve larger and more diverse samples, use multiple different tasks for each construct, and employ a broader range of mathematical contexts to obtain findings with greater generalizability.

CONCLUSION AND SUGGESTIONS

Based on the results and discussion, it can be concluded that mathematical reading strategies were statistically significant in predicting students' mathematical literacy and mathematical problem-solving ability, both partially and simultaneously. Partially, mathematical reading strategies were statistically significant in predicting students' mathematical literacy ($p < 0.001$) and mathematical problem-solving ability ($p < 0.001$). Simultaneously, mathematical reading strategies were also statistically significant in predicting students' mathematical literacy and mathematical problem-solving ability jointly ($p < 0.001$). These findings indicate that mathematical reading strategies have predictive value for students' ability to understand, use, and interpret mathematical information, as well as to solve mathematical problems. However, given the relatively small sample of 31 students from a single class at a public junior high school in Gudo and the use of an *ex post facto* design, the findings should be interpreted with caution. The study also used a single task to measure both mathematical literacy and mathematical problem-solving ability, which may have resulted in some overlap in the responses used to derive the two scores. In addition, mathematical reading strategies were measured using a self-report questionnaire, which may not fully reflect students' actual use of reading strategies. Therefore, the findings should not be regarded as evidence of a causal relationship or broadly generalized to the wider population of junior high school students. Future research is recommended to involve larger and more diverse samples from multiple schools to improve the generalizability of the findings. The use of multiple and different assessment tasks to measure mathematical literacy and mathematical problem-solving ability is also recommended to strengthen the distinction between the two constructs and reduce the possibility of measurement overlap. In addition, future research should employ stronger construct-validation procedures to ensure that the mathematical reading strategy instrument adequately represents the construct being measured. Future research could also consider prior mathematics achievement and general reading ability as control variables so that the predictive ability of mathematical reading strategies for mathematical literacy and mathematical problem-solving ability can be interpretd more accurately. For teachers, mathematics instruction can place greater emphasis on students' mathematical reading strategies through guided reading activities. Teachers can ask students to predict the problem presented in the question before solving it, identify the given and required information and determine which information is relevant, explain the meanings of mathematical terms and symbols contained in the problem, and transform information from the text into mathematical representations, such as tables, diagrams, pictures, or mathematical models. Teachers can also ask students to restate the information obtained from the problem in their own words and check the consistency of the information before determining a solution strategy. These activities can serve as an approach to support the development of mathematical reading strategies as well as the processes of mathematical literacy and mathematical problem-solving among students.

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