25 (3), 2024, 1259-1272

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

Measuring Mathematical Literacy Skills of Indonesian Junior High School Students in Solving PISA-Like Problems

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Abstract: Measuring Mathematical Literacy Skills of Indonesian Junior High School Students in Solving PISA-Like Problems. Objective: In the current digital era, students' mathematical literacy skills are important for every student. This study aims to measure junior high school students' mathematical literacy skills in solving PISA-like problems and to analyze the primary elements contributing to students' challenges in solving mathematical literacy PISA-like problems oriented to the PISA framework. **Methods:** This research uses a qualitative method with a case study design. The subjects are 25 grade-ninth students selected by purposive sampling. Data collection used mathematical literacy tests, interviews, and documentation. The data analysis techniques used are data reduction, data presentation, and conclusion. Data triangulation was also used to verify data validity by comparing test results and interviews to confirm the validity of the data obtained. **Findings:** The primary elements contributing to students' challenges in addressing PISA-like-oriented mathematical literacy difficulties are a lack of familiarity with mathematical literacy questions, and classroom instruction not focused on contextual learning. These issues indicate that students lack exposure to real-world applications of mathematical concepts, which are crucial in developing problem-solving skills. Additionally, the absence of contextual learning means that students are not provided with opportunities to apply their mathematical knowledge to solve practical, everyday problems. **Conclusion:** Students' competency in addressing PISA-like problems related to four contents was low. According to the indicators of mathematical literacy, sixty percent of students could effectively formulate the contextual situation of the problem concerning the quantity of material at levels 1 and 2. Meanwhile, other indicators "employed and interpreted" on shape and space content, data and uncertainty, and change and relationship at levels 3 up to 6 are still in the low category.

Keywords: mathematical literacy, PISA-like problems, PISA framework, junior high school.

▪ INTRODUCTION

Currently, in this complex and dynamic era, mathematical literacy is crucial for academic success and facing real-world challenges. Mathematical literacy encompasses not only the capacity to count but also the ability to develop, apply, and interpret mathematical concepts across many contexts (Harisman et al., 2023; Heryani et al., 2023; Ratnaningsih & Hidayat, 2021; Susanta et al., 2021). Mathematically literate persons can use logical reasoning, discern and evaluate quantitative data, and apply mathematical principles to resolve everyday issues (Steen, 2001).

The Organization for Economic Cooperation and Development (OECD) defined mathematical literacy as the individual capacity to reason mathematically, incorporating the formulation, application, and interpretation of mathematics to address problems across many contexts (OECD, 2022a). Stacey and Turner (2015) asserted that mathematical literacy is the capacity to employ mathematical reasoning to address real-world issues and effectively confront life's challenges. Kilpatrick (2001) stated that proficiency in mathematical literacy is the best way for every student to achieve the learning objectives of mathematics lessons. Students can represent their knowledge in

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DOI: http://dx.doi.org/10.23960/jpmipa/v25i3.pp1259-1272
Received: 22 November 2024
Accepted: 06 December 2024
Published: 16 December 2024

solving mathematical contextual problems with good mathematical literacy ability (Capone et al., 2021).

One of the efforts to measure students' mathematical literacy ability is through the Program for International Student Assessment (PISA) study. PISA (OECD, 2019) is a study conducted by the OECD, which has members of developed countries worldwide, including Indonesia. The OECD's goal in PISA is to measure the reading, math, and science literacy skills of students aged 15 years and under. PISA outlines the components that build mathematical literacy skills through three main components: content, context, and process. The content component of PISA problems includes (1) quantity, (2) shape and space, (3) change and relationship, and (4) data and uncertainty. Meanwhile, the context components of real-life problems include (1) personal, (2) social, (3) occupational, and (4) scientific.

The problem-solving process contained in PISA requires mathematical thought processes and actions such as mathematical concepts, knowledge, and mathematical skills (Ekawati et al., 2020). Solving problems in PISA requires process components that include (1) formulation, (2) employment, and (3) interpretation and evaluation. The word "formulate" refers to an individual's capacity to discern the context of an issue, incorporating mathematical facts and concepts into a mathematical framework. The word "employ" refers to the capacity to utilize mathematical concepts, facts, and processes in resolving problems designed to provide mathematical results. The phrase "interpret and evaluate" refers to the capacity to analyze mathematical solutions, results, or findings and to understand them within the framework of real-world issues that prompted the inquiry.

The PISA results 2022 indicated that Indonesian students achieved a mathematical literacy score of 366, below the PISA standard result of 472 (OECD, 2022b). The students' mathematical literacy scores also decreased by 13 points from the PISA results in 2018, with a score of 379. The PISA results also showed that only 18% of students in Indonesia were able to reach level 2. This percentage is far behind the average OECD country, which reached 69%. Furthermore, very few students in Indonesia achieved levels 5 or 6 on the math literacy test, which represents the most challenging questions provided by PISA. Therefore, it can be inferred that the mathematical literacy skills among Indonesian students remain inadequate.

Indonesian government efforts, the Ministry of Education and Culture (Kemendikbud, 2016) established the School Literacy Action and National Assessment programs to improve students' mathematical literacy competency in Indonesia. The school literacy movement has 6 literacy movement programs, one of which is numeracy literacy. The school literacy movement aims to foster a culture of mathematical literacy in schools and build an ecosystem to become lifelong learners. The National Assessment is an evaluation program implemented by the Ministry of Education and Culture to enhance educational quality by assessing input, process, and output across all educational units. The national assessment comprises the minimum competency assessment, the character survey, and the evaluation of the school learning environment. The minimum competency assessment evaluates students' proficiency in reading literacy and numeracy competencies. This program will serve as an evaluation for the government in evaluating student's competency related to mathematical literacy in Indonesia.

Currently, mathematical literacy stands as a primary emphasis within the Indonesian education system. The contributions of educators and researchers have led to

numerous studies focused on mathematical literacy, aiming to address the challenges associated with low mathematical literacy skills among students in Indonesia. Various mathematical literacy studies have been undertaken with multiple multi-disciplines, such as mathematical literacy research related to STEM (Susanta et al., 2021); ethnomathematics (Runtu et al., 2023; Umbara et al., 2023); augmented reality (Pujiastuti & Haryadi, 2023); creative thinking (Agustina et al., 2024); realistic mathematics education (Rusdi et al., 2020); and various mathematical literacy research analyses (Domu et al., 2023; Harisman et al., 2023; Heryani et al., 2023; Murtiyasa & Perwita, 2020).

According to the National Centers of Education Statistics (NCES) page (https://nces.ed.gov/surveys/pisa/), PISA will conduct a mathematical literacy assessment again in 2025. Hence, it is essential to research students' mathematical literacy within the PISA framework to assess the current state of their mathematical literacy skills. This research aims to evaluate students' mathematical literacy competencies in addressing mathematical literacy challenges according to the PISA framework. This research focused on the following questions:

RQ1: How are the current student's mathematical literacy skills in solving PISA-like problems oriented to the PISA framework?

RQ2: What are the primary elements contributing to students' challenges in solving mathematical literacy PISA-like Problems?

▪ METHOD

Research Design and Procedures

This research employed a descriptive qualitative research methodology using a case study design. Qualitative research uses an interpretive or theoretical framework to inform the study of research problems and discuss social problems' meaning and process, specifically in solving mathematical literacy (Creswell, 2018). A case study is an in-depth research method that focuses on a detailed and intensive analysis of one or more cases in a real-life context (Yin, 2009). Through a case study approach, this research will explore more deeply and specifically how students' abilities in solving mathematical literacy problems and the difficulties students experience when working on PISA-like problems. The stages used in this study are data collection techniques, data analysis, and interpretation of the outcomes. Data collection techniques in this research used mathematical literacy test instruments, interviews, and documentation. The students' mathematical literacy test data will be assessed by the average formula and then qualified the percentage of each element according to the criteria established by Morris & Gibbon (1978) shown in Table 1.

Table 1. Percentage average criteria of mathematical literacy test

Score Average (%)	Criteria
$M > 75$	High
$50 < M \leq 75$	Medium
$25 < M \leq 50$	Low
$M \leq 25$	Very Low

Note: M as mean scores

Through the analysis of mathematical literacy test results, students who represent the test results on each mathematical literacy content will be selected for interviews. The interview used in this study is a semi-structured interview. A semi-structured interview allows the researcher to dig deeper into the research participants (Madhuriet al., 2022). The results of the mathematical literacy test, interviews, and documentation studies will be triangulated to verify the validity of the data by comparing the test results and interviews to ensure the validity of the data obtained.

Participant

The participants in this study were 25 ninth-grade students from a private junior high school in Bandung City, West Java province. This study was conducted for approximately 1 month in September 2024. The research subjects were selected by purposive sampling. Purposive sampling is a research methodology that focuses on the characteristics of the subjects in alignment with the study objectives (Creswell, 2018). The selection of research subjects was predicated on the premise that ninth-grade students have engaged more comprehensively with the content about quantity, shape and space, change and relationship, and data and uncertainty as a framework for PISA contents.

Instruments

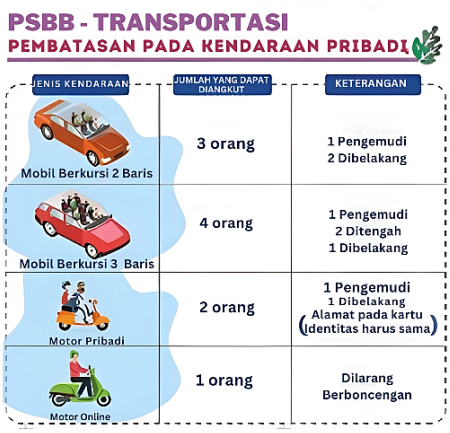
The primary data source in this research was mathematical literacy test instruments. The test instruments consist of four problems oriented to PISA content, namely quantity, shape and space, change and relationship, and data and uncertainty. The four problems in this study are integrated into indicators of mathematical literacy, represented in Table 1.

Table 2. Mathematical literacy instrument framework

Question	Indicators	Content	Context	Level
1	Formulating the problem context entails comprehending the situational context of the problem.	Quantity	Occupational	1-2
2	Employing mathematical concepts, principles, methods, and reasoning encompasses devising problem-solving techniques and executing mathematical computations.	Space and Shape	Personal	5-6
3	Analyze and evaluate mathematical outcomes in line with the problem's context.	Data and uncertainty	Social	3
4	Analyze and evaluate mathematical outcomes in line with the problem's context.	Change and relationship	Personal/ Occupational	4

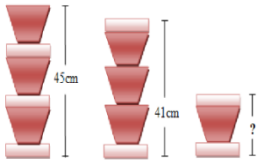
The four mathematical literacy problems similar to PISA problems are taken from everyday contextual problems in Indonesia. The four questions can be seen in the following.

1. The following figure shows the restrictions on private vehicles implemented in some parts of Indonesia in 2020 (Pandemic situation). (Source: Pitaloka, 2024)



a. What can you tell based on this information? Please write it down completely.
b. How many vehicles are needed to carry at least 8 passengers (**excluding the driver**)? Give your reasoning.
(Level PISA: 1-2, Content: Quantity; Context: Personal; Process: Formulate)

2. Look at the following image below.



In the picture there are 3 flower pots arranged with different heights. Note that the flowerpots are composed of two shapes, namely rectangular and trapezoidal. Calculate the height of the smallest flowerpot.
(Level PISA: 5-6; Content: Shape and space; Context: Personal; Process: Employ)

3. Look at the following image which is information related to the development of COVID-19 on June 27, 2021.

The daily death toll from Covid-19 on June 27, 2021, increased by 409 people. Meanwhile, the total number of deaths has been 57,138 people who died from Covid-19. Daily positive cases increased by 21,342 people a day. New cases were detected from 98 thousand specimen tests. In total, more than 2 million people have been infected with Covid-19 in the country. The number of active cases now remains in the hundreds of thousands of people. The number of suspected patients is 129,891 people. Daily recovered patients increased by 8,024 people and the total recovery rate was 1,850,481 people.
Based on the information above, are the following statements true? Circle yes or no, then show your mathematical calculation process.

Statement	Response
There are a total of 2.113.170 positive Covid-19 patients in Indonesia on June 26. 2021.	True/False
On June 27. 2021. 17 people died every hour due to Covid-19.	True/False

(Level PISA: 3; Content: Data and uncertainty; Context: Social; Process: Interprete)

4. Ibnu collected information about the fees offered by three online taxi companies in the city. The information he managed to get is as follows:

Taxi	Initial Fare	Fare per Km during peak hours 07.00 - 09.00 and 15.00 - 18.00	Fare per Km outside peak hours
White Bird	5.000 IDR	4.500 IDR	3.000 IDR
Green Bird	5.500 IDR	4.000 IDR	3.000 IDR
Express Bird	6.000 IDR	4.000 IDR	2.500 IDR

Ibnu will visit his grandmother's house. The distance between Ibnu's house and his grandmother's house is 10 km. He plans to leave at 4 PM. Based on this information, which is the cheapest taxi Ibnu can choose to travel to his grandmother's house? (Level PISA: 4; Content: Change and Relationship; Context: Personal / Occupational; Process: Interprete)

The four mathematical literacy problems have been validated by the supervisors, who are experts in the field of mathematics education. Through a minor revision process based on the results of expert validation, the literacy test instrument can be given to the research subjects.

Data Analysis

The data analysis techniques used in this study followed the Miles and Huberman model are data reduction, data presentation, and conclusion. Firstly, data reduction is carried out by selecting relevant data while discarding unnecessary information from the mathematical literacy test and interview results were carried out. This process results in a clear description of the data, which facilitates researchers in analyzing and drawing conclusions from the study. Secondly, data presentation data is done by classification and identification to draw conclusions based on indicators of students' mathematical literacy skills. Lastly, conclusions were formulated as a detailed form of students' literacy abilities, the specific factors affecting these abilities, and the teaching strategies and approaches adapted to local contexts that can be implemented to enhance students' mathematical literacy.

▪ RESULT AND DISSCUSSION

The 25 student answer sheets were evaluated and scored according to the average score percentage from the mathematical literacy test oriented to the PISA framework. The criteria of the mathematical literacy test are specifically based on the content of the mathematical literacy PISA framework. The results of the mathematical literacy test, as well as their performance in solving PISA-like problems oriented to the PISA framework, are shown in Table 3.

Table 3. Results of the mathematical literacy test

Question	Content - Context	Total Scores	Average Scores (%)	Criteria
1	Quantity - Occupational	240	60%	Medium
2	Shape and space - Personal	96	24%	Low
3	Data and uncertainty - Social	208	52%	Low
4	Change and relationship - Personal/Occupational	160	40%	Low

RQ1: How are the current student's mathematical literacy skills in solving PISA-like problems oriented to the PISA framework?

The test results indicated there are variations in students' performance in solving mathematical literacy problems across different mathematical literacy content areas. Table 3 shows that 60% of students could formulate the context situation of mathematical literacy problems (Level: 1 – 2, content: quantity content, context: occupational) in the medium category. That is the highest percentage of the others. Most students can understand the reading information entirely and write it into the answer sheet. This indicates that students have good reading comprehension skills, which impacts the results of student answers on the document sheet. However, some students could not formulate the context problem and the information in the picture entirely. Students only wrote a little information and only as much as possible. These results are also consistent with (Sa'diyah et al., 2024) that students are still struggling to comprehend and process the information required to formulate mathematical situations. This indicates that students' reading literacy skills are essential for improvement. The ability to read comprehensively is a critical factor in supporting students' mathematical achievement (Prabowo et al., 2023). In addition, it can also improve students' self-confidence and attitudes in solving math problems (Öztürk et al., 2020).

Table 3 revealed that students' level 3–4 mathematical calculation interpretation and evaluation skills remain poor regarding social, change, and relationship topics. Most students can dig up information in the data and uncertainty-social content and only answer questions in the yes/no section. However, they did not perform mathematical calculations and did not interpret according to the context of the problem. In contrast to the change and relationship content, 10 out of 25 students have done mathematical calculations and interpreted the context of the problem. Still, most students have been unable to analyze and evaluate the situation according to the context.

In shape and space content, personal context, and levels 5 and 6, only 24% can apply mathematical concepts and procedures in solving the given problem; this percentage is the lowest percentage of the others. Only 6 out of 25 can apply mathematical concepts and methods to perform mathematical calculations. Most students could not write down ideas and calculations in algebraic form to solve the problem context. These findings also align with (Yustitia et al., 2024) that most students do not write down the concept of mathematical models, including mathematical formulas. The study results also inlined with (Dewantara, 2015; Heryani et al., 2023), revealed that students struggle to solve mathematical literacy problems at levels 5 and 6. The above results showed that students' mathematical literacy skills are still not optimal for solving mathematical literacy problems based on the PISA framework. The analysis of students' answer sheets and interviews with students related to the mathematical literacy test oriented to the PISA-like problems can be seen in Figures 1 and 2.

Figure 1 shows that students had written the information in the picture well, which indicated that students had understood the reading information entirely so that students could formulate the problem correctly. The subsequent results pertain to interviews conducted with students, which align with their response sheets.

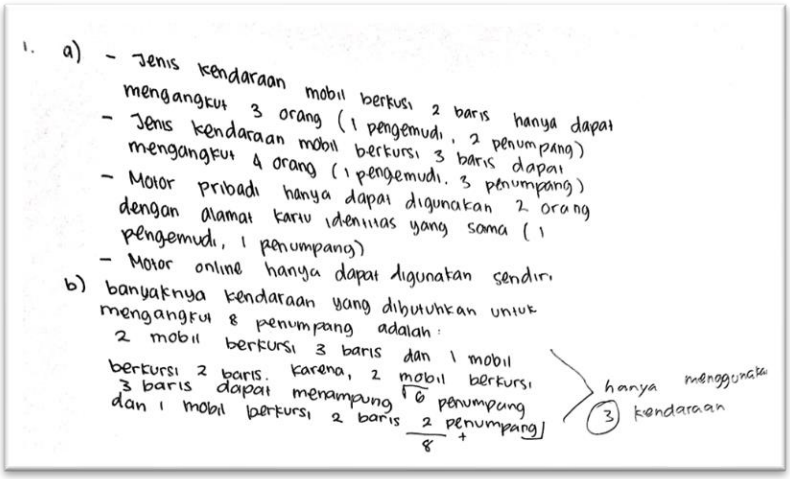


Figure 1. Student-1 answer sheet on quantity

R : What is the context about?
S-1 : Restrictions on private vehicles in the 2020 covid-19 pandemic.
R : What information do you obtain regarding the problem?
S-1 : Two-row-seat vehicles can carry 3 persons (1 driver, 2 passengers). Three-row vehicles can carry 4 people (1 driver, 3 passengers). Personal motorcycles are only used for 2 people with the same address on the identity card (1 driver, 1 passenger). Online motorcycles do not carry passengers.
R : What is being asked about it? Explain your answer.
S-1 : How many vehicles are needed to carry at least 8 passengers, excluding the driver? My answer is that the number of vehicles required to have 8 passengers is 2 three-seater cars that can take 6 people and 1 two-seater car that can hold 2 people. So only 3 vehicles are used.

Figure 2 shows that students performed calculation procedures without first writing the formula concept mathematically. Students still make errors in solving problems by placing mathematical symbols or numerals. Students have interpreted or given conclusions to the results of the calculations carried out but have not been accurate following the context of the problem. This finding is inlined with Kusmaryono & Kusumaningsih (2023) research that students need to improve their understanding of mathematical symbols and mathematical language.

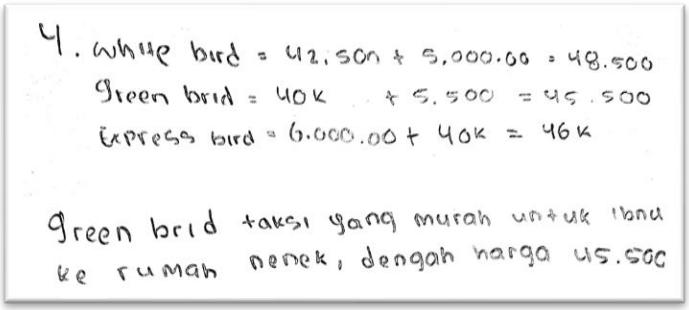


Figure 2. Student-2 sheet answer on change and relationship

The following are the results of interviews with students that correspond to student answer sheets.

R : What is the context about?
S-2 : Taxi rate.
R : What information do you obtain regarding the problem?
S-2 : The initial White bird taxi fare is Rp 5,000, the initial Green bird taxi fare is Rp 5,500, and the initial Express bird fare is Rp 6,000 with additional fares at certain hours, as shown in the table.
R : What is being asked about it? Explain your answer.
S-2 : What is the cheapest taxi Ibnu can take to his grandmother's house? I immediately multiplied 10 km by each initial taxi fare and added the surcharge at 4 PM. Then, I chose the cheapest taxi fare, Green Bird.
R : Why don't you write the formula concept mathematically first?
S-2 : I was confused about how to write it, sir. So, I just calculated it logically.

RQ2: What are the primary elements contributing to students' challenges in solving mathematical literacy PISA-like Problems?

The findings of this study indicate that student's ability to complete mathematical literacy in the like-PISA framework is still low. Interviews with students and teachers indicated that the main issues contributing to students' difficulties in solving PISA-oriented mathematical literacy problems are a lack of familiarity with mathematical literacy tasks and classroom instruction not being oriented towards contextual learning. These issues indicate that students lack exposure to real-world applications of mathematical concepts, which are crucial in developing problem-solving skills. Additionally, the absence of contextual learning means that students are not provided with opportunities to apply their mathematical knowledge to solve practical, everyday problems. Many factors can contribute to the low mathematical literacy skills of students in Indonesia. This issue needs to be examined from various aspects, such as cognitive and affective factors, to identify the elements that may hinder students' ability to solve mathematical literacy problems.

The interview results with teachers also revealed specifically that students are not accustomed to being given mathematical literacy problems in class. These results indicate that mathematical literacy is still the biggest challenge for mathematics teachers and curriculum stakeholders to optimize students' mathematical literacy skills for the PISA 2025 assessment. This result inlined to (AlAli & Wardat, 2024) stated that educators could incorporate PISA-like issues into their instruction to familiarise students with solving and comprehending similar types of problems. Zulkardi and Kohar (2018) also explained that many designs in Indonesia have worked on PISA-like problems and have helped make these materials available to students to enhance their mathematical literacy.

(Umbara & Suryadi, 2019) revealed that the main factor of students' inadequate competency in mathematical literacy on PISA results from a lack of contextualized mathematical literacy instruction that facilitates critical thinking. This inlined to (Leton et al., 2020) found that students lack engagement with contextual problems, understand of basic mathematical concepts, and have difficulty reading and understanding problems effectively. Another study highlighted that teachers in Indonesia face challenges in student numeracy skills where teachers need a good understanding of mathematical

concepts and definitions and conduct contextual learning activities to solve everyday problems (Adelia & Putri, 2024). Therefore, teachers must be equipped with a strong understanding of mathematical concepts and adopt instructional strategies that prioritize contextual and critical thinking tasks. Collaboration among educators, curriculum developers, and stakeholders is essential to bridge this gap and prepare students for the PISA 2025 assessment.

Discussion

Mathematical literacy has become a significant worldwide education, and Indonesia is n outlier. This capability is essential for preparing pupils to confront the complexities and uncertainties of the 21st century (Maryani & Widjajanti, 2020). This issue is indeed complex. Mathematical literacy is not only a matter of modelling the context of problems in everyday life into mathematical models but must be able to reason and solve problems (Steen et al., 2007). Mathematical literacy is still seen as one's primary tool in addressing real problem contexts and is a top priority for continuing development (Umbara & Suryadi, 2019).

The findings of this study emphasize that students' mathematical literacy skills, particularly within the PISA-like framework, remain underdeveloped. This challenge is interesting to discuss because it is compounded by students' unfamiliarity with mathematical literacy tasks and the lack of contextual learning in classroom instruction. As highlighted by prior studies, addressing this issue requires integrating PISA-like problems into teaching practices to familiarize students with real-world, logic-based problem-solving. Furthermore, enhancing mathematical literacy demands a multifaceted approach, considering both cognitive and affective factors that influence students' abilities.

Also, it is interesting to discuss reading comprehension in relation t improving mathematical literacy abilities. Reading comprehension is also essential for students to improve their confidence and achievement in solving mathematical contextual problems (Öztürk et al., 2020). Based on the findings of (Imam et al., 2013), students' low reading comprehension skills are consistent with their achievement in mathematics. Successful mathematical literacy must begin with an investment in developing reading comprehension competencies (Holenstein et al., 2021). Bohlmann and Pretorius (2008) highlighted that the quality of the school curriculum significantly influences reading and mathematics performance. Mathematics education's efficacy hinges on enhancing pupils' literacy development within schools. The same was conveyed (Beaudine, 2022) that teachers, curriculum designers, and educational practitioners can implement reading comprehension strategies to support students' mathematical literacy achievement.

▪ CONCLUSION

According to the results and discussion above, students’ competency in addressing PISA-oriented challenges related to four contents was low. According to the indicators of mathematical literacy, sixty percent of students could effectively formulate the contextual situation of the problem concerning the amount of material at levels 1 and 2. Meanwhile, other indicators on shape and space content, data and uncertainty, and change and relationship at levels 3-6 are still in the low category.

The interviews with students and teachers revealed that the primary elements contributing to students' challenges in addressing PISA-oriented mathematical literacy difficulties are (1) a lack of familiarity with mathematical literacy questions and (2) classroom instruction not focused on contextual learning. This indicates that the learning done at school has not facilitated learning that facilitates mathematical literacy skills. Hence, the findings of this research offer guidance for educators, educational practitioners, and curriculum developers to create mathematics instruction focused on mathematical literacy, including mathematical literacy reading and context-based problem-solving aligned with PISA standards. This approach aims to familiarize students with comprehending the contextual framework of mathematical problems to enhance their mathematical reasoning and problem-solving skills in mathematical literacy.

This research possesses multiple limitations. This study exclusively included ninth-grade students from a private school in Bandung City. Consequently, the findings of this study may not apply to all students in Bandung City or Indonesia. This study exclusively concentrated on students' mathematical literacy skills in addressing questions based on PISA-like problems. Subsequent research may expand the study's scope by encompassing additional dimensions of students' mathematical literacy, including error analysis, affective factors such as adversity quotient, self-efficacy, disposition, self-regulated learning, motivation, or the correlation with other variables to encompass a more comprehensive mathematical literacy investigation.

This study also has implications for future research. This study can be replicated with a bigger and more varied sample to enhance the generalizability of the findings. This study can concentrate on creating educational instructions to address students' challenges in comprehending and applying fundamental mathematical concepts in mathematical literacy problem-solving. The results of this study can assist teachers, educators, and policymakers in enhancing the quality of mathematics instruction in the region.

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