The 2nd International Conference on Mathematics Education and Technology (ICOMET) 2023
ISSN 2986-8513 | pp. 324-331 (2023)
Publisher: University of Islam Malang

MATHEMATICAL LITERACY SKILLS OF STUDENTS IN SOLVING PISA PROBLEMS: A REVIEW OF LOGICAL-MATHEMATICAL INTELLIGENCE

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ABSTRACT

The aim of this research is to describe students' mathematical literacy skills with high, moderate and low levels of logical-mathematical intelligence in solving PISA problems. The approach used in this research is qualitative with a descriptive research type. Data collection techniques employed include tests and interviews. The subjects of this research are three students from class IX-D and IX-A at MTs An-Nur Bululawang with high, moderate, and low levels of logical-mathematical intelligence. Data validation in this research uses method triangulation by comparing the results of mathematical literacy ability tests and interviews. Based on the data analysis, the following conclusions are obtained: 1) students with high logical-mathematical intelligence fulfill all indicators of mathematical literacy skills; 2) students with moderate logical-mathematical intelligence are capable of fulfilling indicators such as writing and mentioning information in the problems, using symbols, reasoning, designing and applying problem-solving strategies, and writing conclusions; and 3) students with low logical-mathematical intelligence only fulfill indicators such as writing and mentioning information in the problems, reasoning, and have already written conclusions.

Keywords: Mathematical Literacy Skills, Logical-Mathematical Intelligence, PISA

1. Introduction

Education in Indonesia plays a significant role in the nation's progress, particularly in developing the quality of human resources. An excellent human resource is essential for effective and well-planned development across all sectors to shape the future. Education and development are intertwined processes, with education at the center as it aims to produce quality human resources for the nation's development (Statistik, 2020). Hall & Matthews (2008) state that training, education, and knowledge are beneficial for a nation's advancement. Education is a crucial aspect that can enhance the quality of human resources. Therefore, specific assessments are necessary to evaluate and measure the quality of education in a country.

One such assessment to evaluate Indonesia's education on an international scale is the Programme for International Student Assessment (PISA), which refers to a program initiated by countries within the Organization for Economic Cooperation and Development (OECD) (Pratiwi, 2019). PISA is conducted regularly every three years. PISA assesses basic literacy in reading, mathematics, and science, regardless of the national curriculum. The assessment targets 15-year-old students through random sampling (Pratiwi, 2019). The aim of the PISA survey is to evaluate the education systems of various countries by testing students' knowledge and skills.

Indonesia has participated in PISA surveys since 2000. The results of the 2018 PISA assessment for mathematics placed Indonesia at 73rd out of 79 countries, with an average score of 379 (OECD, 2019a). Furthermore, the 2018 PISA results indicated that only 1% of Indonesian students achieved level 5 in mathematics, while students from other countries had a higher

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percentage. For example, China had 44%, Singapore had 37%, and Korea had 21% (OECD, 2019b).

PISA focuses on literacy, emphasizing students' skills and competencies acquired in school that can be applied in daily life and various situations. This means that to solve PISA problems, Indonesian students need the ability to mathematically model real-life situations and select, compare, and evaluate appropriate strategies for problem-solving. This mathematical ability is known as mathematical literacy. Additionally, Hera & Sari (2015) states that mathematical literacy is an individual's ability to formulate, use, and interpret mathematics effectively in various everyday problem-solving contexts. Mathematical literacy is considered a crucial component for students to successfully solve PISA problems. It also focuses on students' abilities to analyze, provide reasoning, and effectively communicate ideas, formulate, solve, and interpret mathematical problems in various forms and situations (Khikmiyah & Midjan, 2017).

Students' mathematical literacy skills are related to various factors, one of which is intelligence. In his research, Gardner demonstrated that individuals possess more than one intelligence that can be developed. One type of intelligence is logical-mathematical intelligence. Gardner (2011) states logical-mathematical intelligence involves the capacity to analyze problems logically, carry out mathematical operations, and investigate issues scientifically. This quote indicates that logical-mathematical intelligence encompasses the ability to analyze problems logically, perform mathematical operations, and investigate issues scientifically. Logical-mathematical intelligence can also be understood as the ability to solve problems that require mathematical solutions. Consistent with Gardner's viewpoint, logical-mathematical intelligence includes mathematical calculations, logical thinking, problem-solving, deductive and inductive reasoning, and the recognition of patterns and relationships.

Based on the descriptions provided, this research focuses on students' mathematical literacy skills in solving PISA problems, considering their logical-mathematical intelligence levels. In this context, students' different levels of logical-mathematical intelligence will be the focus of the research to determine and describe their mathematical literacy skills in solving PISA problems. The objective of this research is to describe students' mathematical literacy skills with high, moderate, and low levels of logical-mathematical intelligence in solving PISA problems.

2. Research Methods

This research employs a qualitative approach with a descriptive research type. The researcher uses qualitative descriptive research methods because the aim of this study is to obtain a detailed description and overview of students' mathematical literacy skills in solving PISA problems concerning their logical-mathematical intelligence. The data source for this research comes directly from the primary source, namely, students in grade IX-D and IX-A at MTs An-Nur Bululawang in the academic year 2020/2021. The selection and determination of research subjects occurred after the students took the logical-mathematical intelligence test. Based on the results of the logical-mathematical intelligence test, students were categorized into three groups based on their logical-mathematical intelligence. The systematic process of subject determination in the research was conducted through the following steps. (1) Administering the logical-mathematical intelligence test. (2) Grouping students based on their logical-mathematical intelligence. (3) Selecting one student with good communication skills from each category as the research subject. Tables 1 and 2 below show the criteria for logical-mathematical intelligence and the selected research subjects.

Table 1. Criteria for Logical-Mathematical Intelligence

Score	Category
$80 \leq s \leq 100$	High
$60 \leq s < 80$	Moderate
$0 \leq s < 60$	Low

Table 2. Research Subjects

No	Code	Class	Logical-Mathematical Intelligence Level
1.	ST	IX-A	High
2.	SS	IX-D	Moderate
3.	SR	IX-A	Low

Data collection techniques in this research were conducted using tests and interviews. The tests used in this research include the logical-mathematical intelligence test and the mathematical literacy ability test. The logical-mathematical intelligence test was used to obtain data on students' logical-mathematical intelligence. Data on students' logical-mathematical intelligence were used to select research subjects. The mathematical literacy ability test was used to collect data on students' mathematical literacy skills in solving PISA problems. The mathematical literacy ability test was administered to the research subjects.

Instruments used in this research comprise two types: main instruments and supporting instruments. In this research, the main instrument is the researcher, who plays a role in planning, conducting, analyzing data, and reporting the research's findings. The supporting instruments include the logical-mathematical intelligence test questions, mathematical literacy ability test questions, and interview guidelines. The construction of the logical-mathematical intelligence test questions encompasses several topics, including numerical operations, logical reasoning, least common multiple, and great common divisor, number patterns, and numerical reasoning. Meanwhile, the mathematical literacy ability test questions used in this research were developed by the researcher by adapting PISA questions. The selection and development of PISA questions were adjusted to the mathematical literacy skill indicators used in this research.

The validity of the data in this research was ensured using triangulation. Qualitative data analysis is broadly divided into three stages: data reduction, data presentation, and drawing conclusions and verification.

3. Results and Discussion

In this research, the analysis results of students' mathematical literacy skills with high, moderate, and low levels of logical-mathematical intelligence in solving PISA problems are presented as follows.

a. Subject ST

Figure 1 below shows the results of the mathematical literacy ability test for subject ST.

Figure 1. Results of the Mathematical Literacy Ability Test for Subject ST

Based on the results of the mathematical literacy ability test in Figure 1 and the interview with subject ST, the analysis results are as follows. In question number 1, there was one piece of information missing in subject ST's answer sheet, which was the information about the incorrect height data of one student. However, during the interview, subject ST was able to mention all the information known in the question clearly and comprehensively. Subject ST also mentioned that they simply forgot to write down the information about the incorrect height data of one student, which does not imply that subject ST did not understand or know the information. Based on subject ST's statement, the researcher concludes that subject ST can accurately recall the information known in the question, and subject ST also understands what is being asked in question number 1. In question number 1, subject ST was able to use appropriate variables and symbols and create a mathematical model. Therefore, subject ST has fulfilled the first indicator of mathematical literacy ability.

Subject ST demonstrated reasoning and used appropriate problem-solving strategies in determining the actual average height of female students in the class. Thus, subject ST has met the second indicator of mathematical literacy ability. Subject ST was also able to interpret the problem-solving results back into the real-world context and has evaluated all the problem-solving steps. Therefore, subject ST has fulfilled all the indicators of mathematical literacy ability in question number 1.

Based on the test results and the interview with subject ST in question number 2, it can be concluded that subject ST has fulfilled all the indicators of mathematical literacy ability. This is evident from subject ST's ability to write down and mention all the known information about distance, speed when going up, speed when going down, and return time in the question clearly and comprehensively. Subject ST also understands what is asked in question number 2. Subject ST was able to model the problem in question 2 by creating a mathematical equation. In the problem-solving steps, subject ST used variables and symbols to represent speed, distance, and the sought-after time.

Subject ST conducted reasoning and employed the appropriate problem-solving strategy in determining the departure time. The final result of subject ST's problem-solving in question number 2 is correct, and subject ST was also able to interpret the problem-solving results back into the real-world context and evaluate all the problem-solving steps taken to complete question number 2.

b. Subject SS

Figure 2 below shows the results of the mathematical literacy ability test for subject SS.

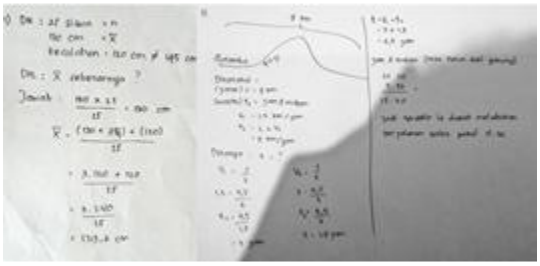

Figure 2. Results of the Mathematical Literacy Ability Test for Subject SS

Based on the results of the mathematical literacy ability test in Figure 2 and the interview with subject SS, the analysis results are as follows. In question number 1, subject SS was able to write down and mention all the known information in the question clearly and comprehensively. Subject SS also understood what was being asked in question number 1. In question number 1, subject SS used appropriate symbols to represent the mathematical situation, such as using "n" to indicate the number of female students and the symbol $\bar{x}$ for the average. However, subject SS did not create a mathematical model to solve the problem in question. Therefore, subject SS only fulfilled sub-indicators 1 and 2 of the first indicator of mathematical literacy ability.

Subject SS met the second indicator of mathematical literacy ability because subject SS performed reasoning and employed problem-solving strategies to determine the actual average height of female students in the class. The method used by subject SS and the formula for calculating the average were correct, although the result obtained was wrong. Subject SS was also able to interpret the problem-solving results back into the real-world context, fulfilling the third indicator of mathematical literacy ability. However, subject SS did not meet the fourth indicator because subject SS did not evaluate the solution to question number 1.

Based on the test results and the interview with subject SS in question number 2, it can be concluded that subject SS has fulfilled all the indicators of mathematical literacy ability. This is evident from subject SS's ability to write down and mention all the known information about distance, speed when going up, speed when going down, and return time in the question clearly and comprehensively. Subject SS also understood what was asked in question number 2. Subject SS was able to use variables and symbols to represent speed, distance, and the sought-after time. However, subject SS did not create a mathematical model for question number 2. Therefore, subject SS only fulfilled sub-indicators 1 and 2 of the first indicator of mathematical literacy ability.

In question number 2, subject SS fulfilled the second indicator of mathematical literacy ability, as subject SS used reasoning by creating an illustrative drawing before solving the problem. Subject SS also used the correct problem-solving strategy in determining the departure time, even though the final result of subject SS's problem-solving in question number 2 was less accurate due to an error in substituting the value of s. The third indicator of mathematical literacy ability was also fulfilled. Subject SS could interpret the problem-solving results back into the real-world context. However, subject SS did not meet the fourth indicator because subject SS did not evaluate the solution to question number 2.

c. Subject SR

Figure 3 below shows the results of the mathematical literacy ability test for subject SR.

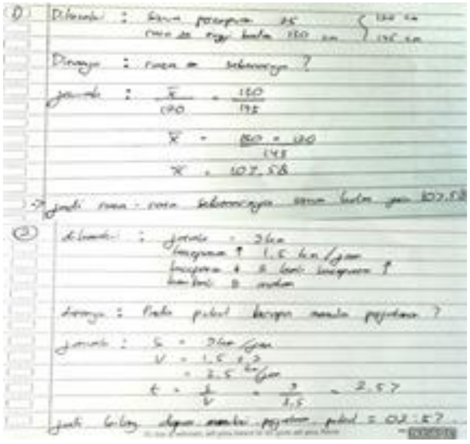

Figure 3. Results of the Mathematical Literacy Ability Test for Subject SR

Based on the results of the mathematical literacy ability test in Figure 3 and the interview with subject SR, the analysis results are as follows. In question number 1, subject SR was able to write down and mention all the known information in the question clearly and comprehensively. Subject SR also understood what was being asked in question number 1. In writing down the information in question number 1, subject SR did not use mathematical variables or symbols to represent the mathematical situation. However, in the problem-solving phase, subject SR was able to use appropriate symbols, such as using the symbol $\bar{x}$ for the average. In question number 1, subject SR did not create a mathematical model to solve the problem. Therefore, subject SR only fulfilled sub-indicators 1 and 2 of the first indicator of mathematical literacy ability.

Subject SR engaged in the process of reasoning to determine the actual average height of female students in the class. However, the strategy used by subject SR to solve question number 1 was incorrect. Subject SR did not use the concept of determining the average value and instead used a comparison approach, disregarding information that could have helped in solving question number 1. As a result, subject SR only fulfilled sub-indicator 1 of the second indicator of mathematical literacy ability. The third indicator of mathematical literacy ability was fulfilled by subject SR, as subject SR could interpret the problem-solving results back into the real-world context. However, subject SR did not meet the fourth indicator because subject SR did not evaluate the solution to question number 1.

Based on the test results and the interview with subject SR in question number 2, it can be concluded that subject SR has fulfilled all the indicators of mathematical literacy ability. This is evident from subject SR's ability to write down and mention all the known information about distance, speed when going up, speed when going down, and return time in the question clearly and comprehensively. Subject SR also understood what was asked in question number 2. In writing down the information in question number 2, subject SR subject SR did not use mathematical variables or symbols to represent the mathematical situation. However, during the problem-solving stage, subject SR was able to use the appropriate symbols to represent speed, distance, and the sought-after time. Subject SR did not create a mathematical model for question number 2. Therefore, subject SR only fulfills sub-indicator 1 and sub-indicator 2 of the first indicator of mathematical literacy skills.

For question number 2, subject SR has not fully met the second indicator of mathematical literacy skills. Subject SR only fulfills sub-indicator 1 of the second indicator of mathematical literacy skills. This is because subject SR engaged in a reasoning process before solving the problem, but subject SR was not able to use the correct problem-solving strategy in determining the time for question number 2. The third indicator of mathematical literacy skills has been fulfilled by subject SR because subject SR can interpret the results of problem-solving back into the real-world context. However, subject SR does not fulfill the fourth indicator because subject SR did not evaluate the solution to question number 2.

Based on the research results on students' mathematical literacy skills, the overall discussion of students' mathematical literacy skills in solving PISA questions, as viewed from their logical-mathematical intelligence, is as follows.

1. Mathematical Literacy Skills of Subject ST

Subject ST falls into the category of students with high logical-mathematical intelligence. The presentation of data and data analysis from the mathematical literacy skills test indicates that subject ST has fulfilled all mathematical literacy skill indicators. In the first indicator (formulating real-world problems), subject ST has identified the elements present in the problem by writing down and stating the known and asked-for information in the problem clearly and comprehensively. When recording the information found in the problem, subject ST also uses variables and symbols appropriately to represent mathematical situations. Furthermore, subject ST can use the available information to create mathematical models. This aligns with Kurniawati & Kurniasari (2019) statement, which suggests that individuals with high logical-mathematical intelligence translate problems into the language of mathematics by recording essential information needed to solve problems.

The second indicator of mathematical literacy skills (using mathematics) has been met by subject ST. Subject ST designs problem-solving strategies by reasoning based on the facts and information available, contemplating the necessary mathematical concepts to solve the problem. Moreover, subject ST applies a detailed, systematic, and precise problem-solving strategy in accordance with the plan. Subject ST is also capable of explaining the steps of the problem-solving process effectively.

The third indicator of mathematical literacy skills, interpreting or understanding solutions, has been fulfilled by subject ST. During the interpretation process, subject ST writes conclusions from the mathematical problem-solving back into the real-world context. Furthermore, subject ST evaluates the entirety of the problem-solving steps to ensure that all steps and answers are correct, conducting re-calculations to verify consistency. Consequently, subject ST meets the fourth indicator of mathematical literacy skills (evaluating solutions).

In conclusion, students with high logical-mathematical intelligence can successfully solve mathematical literacy skill test questions, from formulating real-world problems, using mathematics, interpreting or understanding solutions, to evaluating solutions. This aligns with the research findings of Faizah, Sujadi, & Setiawan (2017), which suggests that students with high logical-mathematical intelligence excel in problem-solving steps, process information effectively, and perform accurate calculations.

2. Mathematical Literacy Skills of Subject SS

Subject SS falls into the category of students with moderate logical-mathematical intelligence. Based on the presentation of data and data analysis from the mathematical literacy skills test, subject SS only fulfills certain mathematical literacy skill indicators. Subject SS can identify the elements present in the problem by writing down and stating the known and asked-for information in a clear and comprehensive manner. This indicates that subject SS comprehends the problem and the sufficiency of the necessary elements to solve it. Subject SS is capable of using appropriate symbols to represent mathematical situations, but subject SS does not use the available information to create mathematical models. Thus, subject SS only fulfills sub-indicator 1 and sub-indicator 2 of the first mathematical literacy skill indicator (formulating real-world problems).

Subject SS has fulfilled the second indicator (using mathematics), albeit with errors. The errors made by subject SS occurred because subject SS did not create a mathematical model beforehand, resulting in errors in solving the problem. However, the concept used by subject SS to solve the problem is correct. This is consistent with Faizah et al. (2017), which suggests that students with moderate logical-mathematical intelligence have fairly good calculation skills but may make planning errors. Subject SS employs reasoning based on available information to devise problem-solving strategies. Subject SS uses illustrative drawings to aid in the reasoning process. The problem-solving strategy used by subject SS to determine the solution is appropriate, although the final result of the solution is still incorrect.

The third indicator of mathematical literacy skills (interpreting or understanding solutions) has been met by subject SS. Subject SS writes conclusions from the mathematical problem-solving back into the real-world context. However, subject SS does not evaluate the entirety of the problem-solving steps conducted to determine the solution. Consequently, subject SS does not fulfill the fourth indicator of mathematical literacy skills (evaluating solutions).

In conclusion, students with moderate logical-mathematical intelligence have not yet fully developed the ability to create mathematical models using available information and do not evaluate the entirety of their problem-solving steps, resulting in incorrect answers. Consistent with this statement, Faizah et al. (2017) indicate that students with moderate logical-mathematical intelligence are suboptimal in using their abilities and may not be precise in problem-solving.

3. Mathematical Literacy Skills of Subject SR

Subject SR falls into the category of students with low logical-mathematical intelligence. Subject SR only manages to fulfill certain mathematical literacy skill indicators. In the first indicator, which is formulating real-world problems, subject SR only fulfills sub-indicator 1 and sub-indicator 2. Subject SR can write down and state the known and asked-for information comprehensively. However, subject SR does not use mathematical variables or symbols to represent mathematical situations when recording this information. Nevertheless, during the problem-solving stage, subject SR can use appropriate symbols. Subject SR is also unable to use the available information to create mathematical models.

Subject SR only fulfills sub-indicator 1 of the second indicator of mathematical literacy skills. This is because subject SR has engaged in reasoning to devise problem-solving strategies. However, the strategy used by subject SR in solving problems is still incorrect. In question number 1, subject SR did not use the concept of finding the average value but instead used a comparison approach. Conceptual errors made by subject SR can occur because subject SR does not yet comprehend the subject matter, in this case, the concept of finding the average value. This aligns with research conducted by Kurniawan (2018), which states that conceptual errors occur among students with low logical-mathematical intelligence, where conceptual errors are one of the common mistakes made by students. One contributing factor to conceptual errors is the lack of student comprehension.

The third indicator of mathematical literacy skills (interpreting or understanding solutions) has been met by subject SR. Subject SR can interpret the results of problem-solving back into the real-world context. However, subject SR does not fulfill the fourth indicator (evaluating solutions) because subject SR does not evaluate the problem-solving solutions. This is consistent with Hapsari, Kurniawati, & Widyasari (2023), which suggests that students with low logical-mathematical intelligence have not fairly good calculation skills.

In conclusion, students with low logical-mathematical intelligence have not yet developed the ability to connect the available information to create mathematical models, experience conceptual errors, thereby struggling to formulate and implement appropriate problem-solving strategies. Furthermore, they do not evaluate the solutions obtained. This statement is supported by Faizah's research findings (2017:22), which indicate that subjects with low logical-mathematical intelligence encounter difficulties in processing information, analyzing, and solving problems.

4. Conclusions

Based on the research results and discussion of students' mathematical literacy skills in solving PISA questions, as viewed from their logical-mathematical intelligence, the following conclusions and recommendations are obtained.

1) Students with high logical-mathematical intelligence fulfill all mathematical literacy skill indicators.
2) Students with moderate logical-mathematical intelligence fulfill indicators related to writing down and stating information in the problem, using symbols, reasoning, designing and implementing problem-solving strategies, as well as writing conclusions.

3) Students with low logical-mathematical intelligence only manage to fulfill indicators related to writing down and stating information in the problem, reasoning, and writing conclusions.

For future researchers, it is recommended to conduct research on students' mathematical literacy skills based on other types of intelligence. The types of intelligence that can be explored include visual-spatial intelligence, linguistic intelligence, and others.

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