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

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Abstract. This study aims to describe students of the junior high school mathematical literacy skills in solving PISA-like problems on number content. PISA-like items are problems created using dimensions in PISA. The method used in this study was descriptive qualitative. The research subject were students of the ninth-grade students in one of the integrated Islamic junior high school in Surakarta, which consisted of six students. The instruments used were tests, interviews and researchers. The results showed that the students' mathematical literacy skills were classified as good for level 1 to 3 and low for level 4 and 5, and very low for level 6. This categorization was based on the number of students who answered the questions correctly at each level. Students in levels 1 to 3 were able to formulate mathematical situations and translate real-world problems into mathematical representations and then are able to choose the right solution strategy. However, when students faced level 4, 5, and 6 level questions, with a higher level of reasoning and complex problem situations, many students still faced difficulties. It has an impact on the students' ability to determine strategies, make many mistakes, and not be able to answer the questions correctly.

1. Introduction

Literacy is a person's ability to read, write, use, and interpret knowledge that has an impact on social intelligence and in increasing competitiveness to face 21st-century skills. Literacy is one of the main competencies needed by students to face the 21st century's challenges [1]. The challenges faced in the 21st century demand fundamental changes in mathematics education[2]. Mathematical skills that students need to know do not only refer to basic calculations, but also how to use mathematics to analyze complex problems, to reach logical solutions, and to estimate the efficiency of different ways to solve a problem.

Mathematical literacy is a person's ability to formulate, apply, and interpret mathematics in various contexts, including the ability to reason mathematically and use concepts, procedures, and facts to describe, explain, or predict phenomena. Mathematical literacy is essential since it helps someone to understand the role or use of mathematics in everyday life as well as to use it to make the right decisions as citizens who build, care, and think[3]. The important part of mathematical literacy is in using, doing, and recognizing mathematics in various situations [4]

Program for International Student Assessment (PISA) is an assessment program initiated by the Organization for Economic Cooperation and Development (OECD), which is an international assessment of skills and knowledge of 15 years old children. PISA is designed to assist the government in monitoring the results of the education system in terms of regular and general student achievement that is nationally and internationally acceptable. PISA assessment includes the assessment of three competencies, namely reading (reading literacy), mathematics (mathematical literacy), and science (scientific literacy). Mathematical literacy in PISA study is defined as a person's ability to reason
mathematically and as a process of formulating, implementing, and interpreting a problem in various real-world contexts [3]. PISA has its own measurement in making questions and knowing students' mathematical literacy abilities, in which these abilities include three dimensions, namely context, content, and process. The three dimensions are described as follows: 1) situation or context, which is a situation that describes the problem itself; 2) content, which is interpreted as mathematical content or material; 3) process, which is interpreted as the steps to solve a problem. Through the operationalization of the mathematical literacy construct, PISA voiced a vision of education that prepares all future citizens to lead productive and satisfying lives [5].

Mathematical literacy skill is essential because it can help to solve everyday problems. It needs habituation continuously, which is packaged systematically through problem-solving in order to build a culture of literacy, including mathematical literacy [6]. Mathematical literacy is as functional, problem solving, mathematical thinking, reasoning, argumentation, mathematical skills, conceptual understanding, and mathematical literacy as motivation to learn mathematics [7]. Mathematical literacy is needed, not only limited to understanding arithmetic but also mathematical reasoning and problem-solving, as well as logical reasoning to solve problems in everyday life [8]. The process of mathematical literacy begins with identifying problems in context and formulating problems mathematics based on the concepts and relationships inherent in the problem. Then, it continues with the process of working, interpreting, and evaluating [9].

The low achievement of Indonesian students in the PISA study can be seen from the test rankings in 2018, where Indonesia is still low. For the mathematics category, Indonesia is in a lower rank with an average score of 379. This indeed becomes a concern of various groups, both the government and education observer. Several factors, namely, cause the low results of students' PISA studies in Indonesia, students are not used to working on PISA model mathematics problems, and students also have difficulties in communicating and representing problems in various contexts [10]. The low mathematical literacy of junior high school students in several provinces in Indonesia is also shown by the research results of the Ministry of Education and Culture’s Research and Development Agency. However, the test design used has been adapted to the Indonesian context [11]. Based on the data that happened in the study, this study tries to examine the mathematical literacy abilities of junior high school students in solving PISA-like questions on number content. By knowing the map of students' mathematical literacy abilities, it is expected that it can provide input to educators to determine the level of student characteristics in improving students' mathematical literacy abilities.

2. Method
The method used is descriptive qualitative. Qualitative research describes students' mathematical literacy abilities. This research was conducted at one of the integrated Islamic junior high schools in Surakarta. The purpose of this study was to describe the mathematical literacy skills of ninth-grade students in solving PISA-like questions. The subjects of the research were six students, taken from those who gave complete answers and more information from the written test. The test contained six essay items with mathematical literacy skill indicators. The arrangement of PISA-like questions were done by the researcher by using the standard decided by PISA. The questions were validated by the experts and revised to have the valid results. The collecting data methods used were tests and interviews. Data validation was done by triangulation methods. The results of the written test and interview were then analyzed using mathematical literacy skill indicators to know how the students used their mathematical skills to solve the problems. The students answered the questions. After the answers were gotten, the researcher classified the answers and analyzed them, then conducted interviews. The data analysis was done by analyzing the data, choosing, and finding the patterns. This data analysis was done continuously until the data were saturated. Indicators of mathematical literacy skills used levels in PISA. PISA divides the level of proficiency into six levels, level 1 is the lowest, and level 6 is the highest level, so the higher the level of students have, the higher their mathematical literacy skills are, and vice versa [12]. The Proficiency scale descriptions for mathematics is shown at Table 1:
## Table 1. The proficiency scale descriptions for mathematics

| Level | Description |
|-------|-------------|
| 1     | Students can identify information and complete routine procedures according to relevant and explicitly presented instructions |
| 2     | Students can identify the relationship between relevant textual information and data to solve problems, interpret, and apply simple models. |
| 3     | Students use the solving process by developing simple strategies and procedures, understand the problems given, use a certain formula, and use simple reasoning. |
| 4     | Students can perform calculations that involve and use procedures, perform calculations that involve reasoning, and are able to provide explanations and communicate them. |
| 5     | Students can use a broad range of thinking and reasoning, reflect on what they are doing, and are able to communicate it. |
| 6     | Students can develop strategies for solving problems, formulate conclusions, arguments, and appropriate explanations, and interpret and understand information with a high level of reasoning. |

### 3. Results and Discussion

The research results were obtained from the students' mathematical literacy ability test and interviews. The test is given in the form of PISA-like questions on number content, which consists of questions level 1 to level 6. The following are the results of the analysis of the students' works.

#### 3.1 Problem 1: mathematical literacy skills level 1

This question is classified as a problem with a low level of reasoning but requires representation skills that must be mastered by students. All the information needed to answer the questions has been presented in the questions and still uses simple mathematical operations. The following questions are presented:

"A furniture store provides a variety of equipment, one of which is a bookshelf. The shop offers a complete bookcase for Rp. 120,000 - or you can design your bookshelf by buying plywood, wood glue, and sandpaper. The price (in IDR) details are as follows: plywood price is 50,000 or 60,000; Wood glue is 45,000 or 30,000 and Sandpaper is 8,000 or 5,000. The command in the question is to find a minimum price if you are going to design your own bookshelf?"

![Figure 1. Problem number 1](image_url)

To solve this problem, students can compare the minimal costs between designing their bookshelf and buying a complete bookshelf directly.

| Known: total price IDR 120,000.00 |
|-----------------------------------|
| Material price: plywood = 50,000/60,000 |
| Wood glue = 45,000/30,000 |
| Sandpaper = 8,000/5,000 |

| Asked: buy a bookcase in lowest price. |
|----------------------------------------|
| Answered: total= IDR 120,000.00 |
| material= 50,000+30,000+5,000= 85,000 |

So, minimum price that Doni must to pay is IDR 85,000
Based on the data analysis, $S_1$ could identify the information in the question and used frequent procedure to solve it. The students could choose the minimum cost; then, it is operated with adding, comparing, and summarizing. Although there are some subjects who have not done the calculations correctly, however they could answer the question with the correct procedure and structured steps. The results of the interviews show that $S_1$ could understand the explicit information in a question, they could also provide the reasons and act based on the given stimulus, so the students' mathematical literary skill in level 1 is considered as good.

3.2 Problem 2: mathematical literacy skills level 2

"A house will be rented out with an annual rental price of 8 million rupiahs. Homeowners provide options in payment transactions. The first option is the payment, which is made in 2 stages with the same amount. The payment in the first stage is given a 50% discount, but in the second stage, it remains. The second option is a one-time payment with a 30% discount. Which one can be selected to reduce the rental cost?"

**Figure 3. Problem number 2**

In this question, assistance is no longer given in the form of factual information that can be concluded immediately, but students must process the relevant information in the problem to get a solution. The following is the form of the questions presented:

To solve this problem, students must know the final cost of each payment option.

| 1. Known: a house is rented in IDR 8,000,000/ year. |
|--------------------------------------------------|
| - option 1: in 2 steps                           |
|   step 1: 50% off                               |
|   step 2: fixed price                            |
| - option 2: 1 x 30% off price                    |
| 2. Asked: which one can be chosen to get lower-cost? |
| 3. Answered:                                    |
|   option 1 => step 1 =                           |
|     step 1 = 4,000,000                            |
|     total = 2,000,000 + 4,000,000 = 6,000,000    |
|   option 2 => total = 8,000,000 – 2,400,000 = 5,600,000 |
| So, to get lower-cost we can choose option 2 (IDR 5,600,000) |

**Figure 4. The result of $S_2$**
Based on the data analysis, $S_2$ could solve the questions correctly. The students could implement the basic algorithm and use simple models to solve the problem. After realizing the situation in the context, then, the students chose the payment method with the least cost by calculating the cost in each option. Similarly, in the interviews, the students could provide the reasons directly and interpret literally; they could explain the problem-solving strategy systematically. It shows that the students can identify the relation between relevant textual information and data to solve the problems and then apply simple models and communicate the answer.

3.3 Problem 3: mathematical literacy skills level 3

The problem at level 3 is related to the student's ability to interpret the questions given into the real world. The following is the form of the questions presented:

"One school in Indonesia will send one of its students to Japan as a representative in student exchange activities for 3 months. The student needs to exchange some Indonesian rupiah (IDR) into the Japanese Yen (JPY). The exchange rate from Indonesian Rupiah (IDR) to Japanese yen (JPY) is as

Figure 5. Problem number 3

To solve this problem, the students must understand the concept, know the completion plan, and be able to design strategies that will be used.

Known: student will exchange 800,000 rupiah into Yen. 1 rupiah = 0.0074 jpy

Asked: how many yen will the student get?

Solution:

$$800.000 \times 0.0074 = 5920 \text{ JPY}$$

Figure 6. The result of $S_3$

Based on the data analysis, $S_3$ could solve the questions correctly. The student could interpret the information in the question, so they could understand the next step used to achieve the correct answer. The test result showed that the student could do the procedure well. They knew that the first step after understanding the question was to multiply the exchange rate of the money. Based on the interview, the student could give reasons why they used the strategy, which was 1 IDR is 0.0074 Yen. They could communicate the result, interpret, and reason, so the students' mathematical literacy skill in level 3 is considered as good.

3.4 Problem 4: mathematical literacy skills level 4

Problems in level 4 are classified as questions that require high reasoning, although they are not too complex. Problem number 4 requires students to be able to represent their answers and relate them to real situations. The following is the form of the questions presented:
“Pak Andi plans to withdraw money from an ATM in the amount of Rp. 600,000. Mr. Andi will take a nominal amount of Rp 100,000 and Rp 50,000 at once. ATM A can be used to withdraw money in the amount of IDR 100,000, and ATM B can be used to withdraw money in the amount of IDR 50,000. Determine the number of variations that can be taken.”

**Figure 7. Problem number 4**

In this question, many students had difficulties in interpreting the information and commands presented. One example of the students’ completion is as in Figure 8 below:

| **Known:** |  |
| --- | --- |
| will take the money in the amount of 600,000  |  |
| will take money consisting of 100,000 and 50,000  |  |
| ATM A can 100,000  |  |
| ATM B can 50,000  |  |
| **Asked:** how many variations can be taken.  |  |
| **Solution:**  |  |
| 600.000 - ATM A = 100.000 x 6 = 600.000  |  |
| - ATM B = 50.000 x 12 = 600.000  |  |
| Can 6 + 12 = 18 Variations.  |  |

**Figure 8. The result of S_4**

Based on the results of this work, it shows that S_4 had not been able to understand the information in the questions. The assumptions made were still inaccurate, so the students were not able to work effectively with the implied model.

R: Researcher, S_4: Subject 4

R : What was questioned in the question?
S_4 : The number of variations which can be done.
R : What kind of information did you use to answer it?
S_4 : The information of the nominal of the money which can be withdrawn and the nominal which can be withdrawn from ATM A and ATM B
R : What was the first step you did?
S_4 : First, divided it by two, take ATM A and the other from ATM B. Then, the ones from ATM a were added to the ones from ATM B
R : Why should it be added?
S_4 : Yes, because the question was about the variation
R : In this question, in your opinion, what is a variation?
S_4 : Variation is like styles. Maybe it is like that, I couldn’t explain it.
Based on the results of the interview, it was found that S_4 had not been able to understand the meaning of the questions, that the variation in the question was not the number of bills taken but was a different way of taking that could be done. Some students understood the information, but they could not formulate and apply their fact concept and rationale. There was also a student understanding what 'variation' means, but they still faced difficulties in making the solving model. The students could not build and communicate their explanations and opinion based on their result and act. It shows that the students cannot explain and give the reason for their works, so the students’ mathematical literacy skill in level 4 is considered as less profitable.

3.5 Problem 5: mathematical literacy skills level 5

Problems at this level require students to connect mathematical knowledge and skills and be able to reflect on statements in problems using their knowledge and then communicate them. The following is the form of the questions presented:

"A home hijab convection is capable of producing 1,000 headscarves in 8 days. Each production process consists of several divisions. When examining the hijab, there is a damage/defect at the final stage.

The number of hijab damage

Based on the table, is in 8 days the total damage 80 hijab?"

Figure 9. Problem number 5

Based on the analysis of the answer, many subjects could not answer the question correctly. The students had difficulties in choosing the strategy, although they were some strategies that could be used. Problem number five is also a problem with a high level of reasoning, which requires a wide range of thinking results.

Figure 10.a. The result of S_5

Known: (Subject rewrote the problem)
Asked: whether in 8 days there were 80 hijabs in total?
Answered: 50 + 150 + 175 + 125

Figure 10.b. The result of S_4

Known: (Subject did not write down the known)
Asked: whether in 8 days there were 80 hijabs in total?
Answered: 4 + 12 + 10 + 14 = 40
From the results of subject S5 (See Figure 10.a) it can be seen that the students could not develop strategies and work with broader situations. The students were confused in choosing problem-solving strategies when dealing with complex situations and related to the model, therefore the way students uses was to add them. The results obtained were not accurate and students could not communicate the results of their work. Then, it can be seen from the answer of subject S4 (See Figure 10.b.), the students also could not communicate why the steps taken must be added up then reduced and have not given clear reasons. The students also could not reflect on what they were doing. Based on the results of the interview, students had difficulties in understanding the questions and finding solutions, then in solving these problems using comparisons, but the students could not provide reasons why they used comparisons. The students should be able and communicate each stage of completion and then conclude with proper arguments. It also shows that students could not apply the concepts in solving problems that have been formulated to obtain mathematical conclusions.

3.6 Problem 6: mathematical literacy skills level 6
In this problem, the students can conceptualize and use information based on complex problem situations. They can apply their understanding in-depth with a high level of reasoning. The following is the form of the questions presented:

"For kawung batik fabric of 8 cm² in length, it is painted with 1 white flower consisting of 4 petals, and then for fabric of 16 cm² in length, it is painted with 4 white flowers consisting of petals, and so on. If the fabric used is wider by the same flower motif as the previous pattern, so which one will increase faster, the fabric length or the number of flowers?"

Figure 11. Problem number 6

To solve these problems, students can develop strategies to determine which one has the most and the fastest increase between the fabric length and the number of flower motifs on the batik. Based on data analysis, all subjects could not answer correctly. The students had difficulties in solving the problems at this level, the students could not formulate and connect sources of information. Results of written work and interviews S6.

| Known |
|-------|
| The large of fabric 8cm² = 1 flower |
| The large of fabric 16 cm² = 4 flowers |

| Asked: which one is increasing faster? Is it flower or fabric? |

| Solution : |
|------------|
| The large of fabric because every fabric increase 8cm², then the flower increase oddly in order |
| The proof => 8 cm² =⇒ 1 \( \{ 3 \} \) |
| 16 cm² =⇒ 4 \( \{ 5 \} \) |
| 24 cm² =⇒ 9 |

Figure 12. The result of S6
Based on work results and interviews, $S_6$ had not been able to formulate strategies to determine which one has the most and the fastest increase between the area of the fabric and the number of flower motifs on the batik. Students used a self-constructed pattern then students used a certain model in determining the area of the fabric and the number of flower motifs on batik, and students have not been able to conclude the results of their work. Viewed from the results of student $S_4$ work, the students incorrectly interpreted the information. The students should be able to count each pattern, the pattern of the area of the cloth that increases with a fixed number of 8, then the pattern of the number of flowers increases with an increasing number because the number of flowers is a quadratic number. However, the students connected the number of flowers and the area of the fabric together so that the pattern that students got was incorrect. It also shows that students had not been able to conceptualize and maximally apply their understanding in complex situations. Thus, the students' mathematical literacy skill level 6 is still low.

From the results of the explanation of the data analysis at each level, the results showed that students had difficulties in working on mathematical literacy skills at levels 4, 5 and 6. It was shown by the results of the mathematical literacy skill test that only a few subjects could answer with the correct strategy. Meanwhile, for level 1, 2, 3, most students were able to finish with the correct procedures and strategies. It further supports the fact that average Indonesian students can only work on questions on the PISA model level 3 and below [3]. The findings of this study are in line with the results of previous studies which also show that the level of mathematical literacy skills of students is still low. The students' mathematical literacy skill in Lampung context is still low in solving problems in the PISA model level 4, 5, 6. It can be seen from the results of the study that 20.45% of the 330 (22 x 15) items analyzed were identified as correct answers [10]. The analysis of students' comments in the interviews shows that students still have difficulties in communicating and representing problems into context. The students in Indonesia during the 4 periods of PISA from 2000 to 2009 were only able to answer PISA questions level 1, 2, and 3 and only a few students were able to answer PISA questions level 4, 5, and 6 [13]. Based on the results of research conducted by PISA from 2000 to 2015, it was found that only a few students were able to reach level 4 or above. Meanwhile, most of them were still below level 2 [14].

4. Conclusion

Based on the results and discussion, it can be concluded that the mathematical literacy skills in solving PISA-like number content questions for ninth-grade students of one of integrated Islamic junior high school in Surakarta are suitable for level 1 to level 3 while for level 4 and level 5 are still relatively low then for level 6 is very low. This categorization was based on the number of the students who answered the questions correctly at each level. Students at level 1 to level 3 are able to formulate mathematical situations and translate real-world problems into mathematical representations and then are able to choose the right solution strategies. However, when students face questions level 4, 5 and 6 with a higher level of reasoning and complex problem situations, there are still many students who have difficulties. It has an impact on the ability to search for and use the strategies used. There are still many mistakes
and the answers given are not accurate. The students also have not been able to conceptualize and make correct models in complex situations.

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