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# Investigating middle school students' difficulties in mathematical literacy problems level 1 and 2

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**Abstract.** The background of this study is the lack of mathematical literacy skills of students. The proficiency of students' mathematical literacy skills based on the results of the PISA 2015 study shows that Indonesian students at the proficiency level 1. This fact gave rise to this study which aims to investigate middle school students' difficulties in mathematical literacy problems level 1 and 2. Qualitative research was used in this study. An individual written test on mathematical literacy problems was administered, followed by interviews. The subjects of the study were 61 students grade VII in Bandung and 26 of them were interviewed afterward. Data analysis revealed that students' error in performing arithmetic most frequently observed. Other observed difficulties concerned understanding about algebra concept, applying arithmetic operation in algebraic expressions, and interpreting symbols to represent the unknown. In solving mathematical literacy problems, students use their prior knowledge, although sometimes not relevant to the questions. Based on the results, we suggest that mathematics learning in contextual learning and which invites students to participate in the processes of understanding the concepts.

## 1. Introduction

Mathematics is primarily to assist the human being in understanding and mastering social, economic, a natural problem. In everyday life is often found something which related and needs mathematics to solve daily life problems. The mathematical ability required to solve daily life problems is mathematical literacy. In line with OECD that mathematical literacy helps people to recognize the role of mathematics in the world and to make judgments and decisions needed as citizens [1]. Knowledge and understanding of mathematical concepts are very important, but more important is the ability to solve problems encountered in everyday life [2]. Thus, it is important for students to have the mathematical literacy [3].

Mathematical literacy is defined as the ability of individual's capacity to formulate, apply and interpret mathematics in various contexts involving mathematical reasoning and the use of concepts, procedures, facts to describe, explain and predict phenomena and relate them to daily life [4], [5], [6]. Proficiency in mathematical literacy according to PISA study is divided into 6 levels [1]. This study discusses proficiency of mathematical literacy level 1 and 2. Description of the two levels of mathematical proficiency based on PISA 2015 (OECD, 2016), i.e., students can typically do: (1) at level 1, students can answer questions involving familiar contexts, and able to identify information and



to carry out routine procedures according to direct instructions in explicit situations, (2) at level 2, students can interpret, recognise situations in contexts, can employ basic algorithms, formulae, procedures, and capable of making literal interpretations of the results [1]. However, students' mathematical literacy ability is low [7], [8], [9], based on the results of the PISA 2015 study shows that Indonesian students are at the proficiency level 1 [1].

Students experience errors in solving mathematical literacy problems. The interview was done with one of the mathematics teachers in middle school Bandung. Based on the interview, teacher revealed that students are still difficult in representing a problem situation using a variable in algebra. In accordance with Jupri, Drijvers, and Heuvel-Panhuizen [10] in their research that "the most frequently observed difficulty is the ability to translate between problem situations and mathematical situations".

It is an important issue to find out the reason that causing students making errors in solving mathematical literacy problem. This requires attention and need to know the condition in depth what kind of errors that experienced by students in solving mathematical literacy problems. Students who have been able to apply their knowledge to a problem, may not be applied it in different problems. As Ojose points out that student needs to experience problem-solving processes in different situations and contexts in order to use their skills effectively [11]. Therefore, in the current study, we investigate middle school students' difficulties in mathematical literacy level 1 and 2. The research question of this study is as follows: what are the students' difficulties in solving mathematical literacy problems level 1 and 2?

## 2. Methods

To address the research question, we conducted a qualitative study through an individual written test and interviews. The subjects of the study were 61 students grade VII in Bandung, and 26 of them were interviewed afterward. The instrument consisted of four questions and interview guidelines. The instrument was designed based on the proficiency of mathematical literacy level 1 and 2. Written test is required to collect data or information about the students' work and the whole steps of students' answer in solving the mathematical literacy problems. Furthermore, interviews were conducted with students to strengthen the analysis of mathematical literacy ability.

## 3. Results and Discussions

### 3.1. Analysis of students' responses

Students were asked to solve four questions of mathematical literacy problems. After students finish solving the problem, they also interviewed to clarify their answers. Based on the analysis of literacy mathematics test and interview results, the following describes in detail the analysis of students' response.

*3.1.1. Analyzing of the first questions.* The first question is "Sherly from America is preparing to go to Indonesia for one month to exchange student. She needs to exchange some US dollars (USD) to Indonesian rupiahs (IDR). Sherly knows that the exchange rate between US dollar and Indonesian rupiah is as follows: 1 USD = Rp 13.000 (IDR). Sherly exchange \$250 USD into Indonesian rupiah with this exchange rate. How much rupiah (IDR) did Sherly earn?"

The first question is number concept, and the indicator of mathematical literacy is employing mathematical concepts, facts, procedures, and reasoning [1]. The first question belongs to the proficiency level 1 of mathematical literacy due to students can answer the question involving familiar contexts where all the relevant information is present, and the questions are defined [1]. Students' answer will be analyzed to get the information of students' difficulties in solving mathematical literacy problems.

As an illustration, students' answer presented in Figure 1 below:

$$1 \text{ USD} = \text{Rp } 13.000 \text{ (IDR)}$$

$$250 \text{ USD} = 250 \times 13.000 = \text{Rp } 3250.000$$

**Figure 1.** The answer of AK for the first question.

Students' work in Figure 1 shows that students understand the problems and realize to solve this currency exchange with the multiplication of integers. There are students' errors in performing arithmetic operations. Students' answer presented in Figure 2 below:

$$13.000 \times 250 = 2.250.000$$

**Figure 2.** The answer of NT for the first question.

Based on Figure 2, apparently, the student does not add the number 2 with the number 1 at the end of the multiplication, so that it gets 2.250.000, where the results should be 3.250.000. We tried to illustrate the process of multiplication done by students, i.e., in Figure 3.

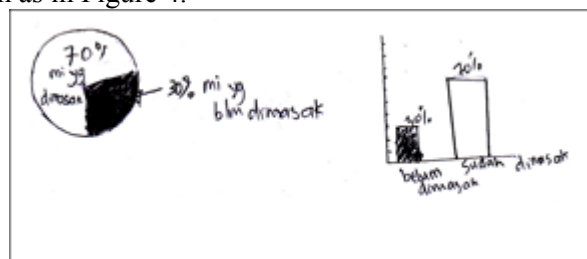
$$\begin{array}{r} 13.000 \\ \times 250 \\ \hline 00000 \\ 65000 \\ 26000 \\ \hline 2.250000 \end{array}$$

**Figure 3.** Illustration of the process of multiplication done by students.

Students' error as in Figure 3 caused by inaccuracy of students in thinking to solve the problem.

*3.1.2. Analyzing of the second questions.* The second question is "Mrs. Dewi has 1 box containing some instant noodles. After instant noodles were cooked, many instant noodles inside the box are 30%. Write a mathematical model with a diagram or symbol stating the number of instant noodles that were cooked!"

The second question is algebra concept, and the indicator of mathematical literacy is formulating situation mathematically [1]. It was designed to represent a situation mathematically, using variables, symbols, and diagrams [1]. Students' work in the second question shows that represent the problem visually, that is a diagram as in Figure 4.



**Figure 4.** The answer of SL for the second question

To clarify students' answer, here is the result of a conversation with the students in the interview process.

R: How do you solve this problem? Can you explain your answer?

SL: Yes, if one box we judge in percentage is 100%, then noodle which not cook is 30%, so noodle which cook is 70%.

R: What makes you think to make a pie or a bar chart?

SL: I am afraid this pie chart is not correct, so I draw a bar.

R: Actually about this diagram is not yet learned in VII grade, what makes you think that you know that the pie chart and the bar chart look like this?

SL: I see it before and in primary school, bar chart ever learned.

Based on the interview, students revealed that they had studied the diagram before at primary. Thus, students use their prior knowledge to solve the problem [12]. None of the students answer by representing a mathematical symbol. There is one thing that became an intriguing question about representing a situation using appropriate symbols, why none of the students show the mathematical symbol on their work? Whereas, algebra is more focused on the relationship between the number and use of symbolic language or called a variable [13]. The absence of the mathematical symbol in the second question corresponds to a previous study which revealed that obstacles and difficulties in algebra are representing the situation symbolically or representing an expression using symbols [14], [15]. Researcher identifies that students' knowledge of the algebra concepts which newly learned in the first semester is not ready to use and need to be improved by doing lots of exercises.

For the second question, there are students that not answer the question. Here is the result of the conversation with students in the interview process.

R: Why this question was not answered?

FZ: Because I don't know, actually question like this is easy, but determine the process is difficult.

R: Which part makes it hard to answer this question?

FZ: When asked to represent a diagram or symbol.

R: Is that hard to represent it?

FZ: But usually already given how many.

According to students who do not answer the second question, it happens because the students are not familiar with the problem that given unknown number. Students have difficulty interpreting and operating symbols or diagrams to represent the unknown.

*3.1.3. Analyzing of the third questions.* The third question is "Riko has time from 15.00 WIB up to 18.00 WIB to do some activities, i.e., having an extra lesson, watching television and doing homework. Riko uses  $\frac{2}{3}$  of his time to go to place for having extra lesson,  $\frac{1}{6}$  of his time to watch television and  $\frac{2}{5}$  of his time to do homework. The most time spent by Riko is watching television. Is it true? Explain."

The third question is number concept, and the indicator of mathematical literacy is interpreting, applying, and evaluating mathematical outcomes [1]. This question was included in the proficiency level 2 of mathematical literacy because students can recognize situations, can employ procedures and capable of making interpretations of the results [1]. Here is the students' answer to the third question as in Figure 5, 6, and 7.

$\frac{2}{3}$   $\frac{1}{6}$   $\frac{2}{5}$   $= \frac{20}{30}$   $\frac{5}{30}$   $\frac{12}{30}$   
 Jadi, pernyataan tersebut salah, karena waktu yang paling banyak digunakan adalah pergi les

**Figure 5.** The answer of NV for the third question

$18.00 - 15.00 = 3 \text{ jam}$  |  $\text{ngajan PR: } 3 \times \frac{2}{5} = \frac{6}{5} = 1\frac{1}{5} = 1,2 \text{ jam}$   
 $\text{les: } 3 \times \frac{2}{3} = 2 \text{ jam}$  |  $\text{Jadi, pernyataan tersebut salah. Yang memakan waktu terbanyak adalah pergi les.}$   
 $\text{nonton: } 3 \times \frac{1}{6} = 0,5 \text{ jam}$

**Figure 6.** The answer of TG for the third question

$15.00 \text{ WIB} - 18.00 \text{ WIB} \rightarrow 3 \text{ jam} \rightarrow 180 \text{ menit}$   

- pergi les  $\frac{2}{3}$  dari 180 menit  $\rightarrow 120$  menit
- menonton televisi  $\frac{1}{6}$  dari 180 menit  $\rightarrow 30$  menit
- mengerjakan PR  $\frac{2}{5}$  dari 180 menit  $\rightarrow 90$  menit

pernyataan : Salah, karena waktu yang paling banyak yaitu pergi les.

**Figure 7.** The answer of TK for the third question

Three different steps found in the third question as in Figure 5, 6, and 7. Three students' works fulfill the process of solving mathematical literacy problems. To clarify students' answer as in Figure 5, here is the result of a conversation with students in the interview process.

R: Do you understand this problem?

NV: Understand.

R: How do you solve this problem? Can you explain your answers?

NV: Looking for the denominator. Find the lowest common multiple first, after that sort it.

Students' work as in Figure 5 show that solves this problem by making the same of denominator by looking for the lowest common multiple. Apparently, students sort the fractions from the smallest to the greatest value before writing the conclusions. Students' work shows that the statement in the problem is wrong, and gave the right reason. The conclusion written in Figure 5 was based on the results of the calculations. Students' work as in Figure 6 shows that solving the problem by multiplied the fraction in the problem with 3 hours. Time 3 hours is obtained from the time difference between at 15:00 pm with 18:00 pm. Students' work in Figure 7 show that multiplying fractions by 180 minutes. 180 minutes is obtained from the time difference from 15.00 WIB to 18.00 WIB is 3 hours. Then 3 hours converted into minute, so obtained 180 minutes. Any fractional in the problem multiplied by 3 hours and the students give a conclusion according to the results obtained.

There are also students who made an error in the multiplication of integers with fraction due to students' inaccuracy, as in Figure 8.

$18.00 \text{ WIB} - 15.00 \text{ WIB}$   
 $= 3 \text{ jam}$   
 = Waktu yang paling banyak digunakan Rito adalah waktu untuk pergi les dan waktu untuk menonton televisi karena untuk pergi les  $\frac{2}{3} \times 3 = 2$  dan untuk menonton televisi  $\frac{1}{6} \times 3 = 2$  kalau untuk mengerjakan PR  $\frac{2}{5} \times 3 = \frac{6}{5} = 1,2$

**Figure 8.** The answer of FR for the third question

Students' work as in Figure 8 shows that made a mistake in the operation of the multiplication of fractions and integers, i.e.,  $\frac{1}{6} \times 3 = 2$ . The error occurred because the students divide six by three, obtained two, and then two multiplied by one equals two. The error in the arithmetic operation



corresponds to Newman's error category, i.e., the error in the process skill, where the student does not perform the mathematical calculation [16]. Students' error because they are inaccuracy in performing the counting operation, that is multiplication between fractional and integer.

*3.1.4. Analyzing of the fourth questions.* The fourth question is "a rectangle badminton field has a length  $(2x+5)$  meters and a width  $(2x-3)$  meters. State the perimeter of badminton field in algebraic expressions"

The fourth question is algebra concept and the indicator of mathematical literacy is formulating situations mathematically [1]. It is included proficiency level 2 of mathematical literacy because students can recognize the situation in rectangle context, which perimeter formula of the rectangle, interpretations using algebraic expressions, and employ procedures arithmetic operation in algebraic expressions. Here is the students' answer to the fourth question as in Figure 9, 10, and 11.

$$\begin{aligned} &2 \times (p+l) \\ &2 \times ((2x+5) + (2x-3)) \\ &2 \times ((2x+2x) + (5-3)) \\ &2 \times (4x+2) \\ &(8x+4) \end{aligned}$$

**Figure 9.** RH's answer for the fourth question

$$\begin{aligned} &2(2x+5) + 2(2x-3) \\ &= 4x+10 + 4x-6 \\ &= 4x+4x-6+10 \\ &= 8x+4 \end{aligned}$$

**Figure 10.** AL's answer for the fourth question

$$\begin{aligned} &(2x+5) + (2x-3) + (2x+5) + (2x-3) \\ &= 8x-3-3+5+5 \\ &= 8x+4 \end{aligned}$$

**Figure 11.** AD's answer for the fourth question

Students' work as in Figure 9, 10, and 11 show the different answer, especially at interpreting the formula. Three different writings the perimeter formula of the rectangle are found for this fourth question. Students' work as in Figure 8 write the perimeter formula with  $2 \times (p+l)$ , Students' work as in Figure 9 write the perimeter formula with  $2p+2l$ , and students' work as in Figure 10 write the perimeter formula with summing up each side. Students use their prior knowledge to solve the problems, and the purpose of mathematical literacy is to measure students' prior knowledge of mathematics concepts [17].

And also, there are students that make an error. Here is the students' answer as in Figure 12.

$$\begin{aligned} \text{Keliling persegi panjang} &= (\text{panjang} + \text{lebar}) \times 2 \\ &= (2x+5 + 2x-3) \times 2 \\ &= +56-15 \times 2 \\ &= 3|22-30 \end{aligned}$$

**Figure 12.** The answer of TG for the fourth question

Figure 12 shows that students' error in applying arithmetic operations in algebraic expressions. To clarify students' answer, here is the result of a conversation with students in the interview process.

R: Do you understand this problem?

TG: No.

R: Why?

TG: Forget.

R: How do you solve this problem? Can you explain your answers?

TG: Anyway the formula is a rectangle if not wrong, length plus width times two. So,  $(2x+5+2x-3)\times 2$ .

R: What makes you think the algebraic calculation is +56?

TG: I don't know.

The student raises the number  $+56-15\times 2$  as the result of the count operation  $(2x+5+2x-3)\times 2$  and does not write the variable  $x$  in the next step of completion. When interviewed, students said did not know where to get the result +56. For the -15 result, students seem to multiply +5 by -3. Then -15 multiplied by two the result is -30. Although students make mistakes in arithmetic operations with algebra expressions, it remains were seen from the results of the answers that students think to get the results. Observed difficulties concerned applying arithmetic operations in algebraic expressions [10]. Arithmetic operations on algebraic expressions according to Newman's error category, i.e., the category of skill process [18].

Also, there are examples of results of students' answers are wrong in formulating a mathematical situation. The error is in interpreting the questioned. Here is the students' answer as in Figure 13.

$$\begin{aligned} &(2x+5) + (2x-3) \\ &(2x+2x) - (5-3) \\ &4x - 2 \\ &x = 2 \end{aligned}$$

**Figure 13.** The answer of FR for the fourth question

To clarify students' answer, here is the result of a conversation with the student in the interview process.

R: Do you understand this problem?

FR: Something like that, Miss.

R: How do you solve it? Can you explain your answers?

FR: This problem about algebra, a rectangle badminton field with length  $(2x+5)$ , and width  $(2x-3)$  meter, and asked the perimeter. My answer was  $(2x+5)$  summed  $(2x-3)$ . But I write  $2x+2x$  minus  $5-3$ , because I collect  $x$ . Then 5 and 3 is not a variable then there is a minus, so  $4x-2$ ,  $x=2$ .

R: What makes you think this length summed with width?

FR: I don't know

Figure 13 shows that students' work which misinterprets the question, so they wrong to formulate the perimeter formula of the rectangle. Students understand that this problem about algebraic. However, not understanding the questions, the students simply add up the known of the problem. The sum process operation is no mistake. This student is correct by collecting the variables. For example,  $(2x+2x)-(5-3)$ . The next step is still correct, i.e.,  $4x-2$ . The error is seen at the time of writing  $x=2$ . It appears that students get the value of  $x$  from result 4 minus 2. For the error as in Figure 13 according to Newman's error category is the transformation problem [18]. Previous research reveals that some students or mistakes most students do on the transformation [15], [19], Things that make students make mistakes that are the inaccuracy of students in thinking.



#### 4. Conclusion

Data analysis revealed that students' error in performing arithmetic most frequently observed. Other observed difficulties concerned understanding about algebra concept, applying arithmetic operations in algebraic expressions and interpreting symbols to represent the unknown. In solving the problem of mathematical literacy problems, students use their prior knowledge, although sometimes not relevant to the questions.

Based on these results, we suggest that in learning process starts with the contextual learning, so that students can understand the concept, and also invite students to participate in the process of understanding the concepts so it is pervasive in students and always remembered for a long period.

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