Teacher Mathematical Literacy: Case Study of Junior High School Teachers in Pasaman

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Abstract. The aim of this paper was to examine the ability of junior high school mathematics teachers to solve mathematical literacy base Problems (PISA and PISA-like problems) for the case Pasaman regency. The data was collected by interviews and test. As the results of this study, teacher ability in solving mathematical literacy base problems for level 1 until 3 has been good, but for level 4 or above is still low. It is caused by teacher knowledge about mathematical literacy still few.

1. Introduction
To compare cross-nationally evidence on student performance, the Organizations for Economic Co-operation and Development (OECD) launched Program for International Student Assessment (PISA) in 1997 [5]. PISA is addressed to 15-year old pupils’ scholastic performance in three domains: mathematics, science, and reading. In each domain, the average score is 500 and the standard deviations is 100 [5].

Since 2000, Indonesia has active in PISA, and the average of Indonesian student performance is always under the total average and outside of the standard deviations, especially for mathematics, for detail see the table below [6].

| Year | Average Score | Indonesian Rank | Total Participants |
|------|---------------|-----------------|--------------------|
| 2000 | 367           | 39              | 41                 |
| 2003 | 360           | 38              | 40                 |
| 2006 | 391           | 50              | 57                 |
| 2009 | 371           | 61              | 66                 |
| 2012 | 375           | 64              | 65                 |
| 2015 | 386           | 63              | 69                 |

Based on the table 1, Indonesian score always in bottom down, even if its slowly increased, from 2009 to 2015. By this result, investigations are needed to find the causing factor or to increase the result. Is the main problem is students, teachers, curricula, or educational systems?

The investigations have been done by several researchers in various approaches. Some Indonesian researchers developed mathematics problems that is potentially increase students’ mathematical literacy [2,7]. And other researchers developed teaching method for some mathematics materials due to mathematics literacy ability [1,3,9]. Differently, in this paper, we investigated teacher ability in solving PISA-like problems. As the main aspect that determine student performance, how if teacher mathematical literacy is not good enough? How can they increase student mathematical literacy?
2. Theoretical Framework

Traditionally, literacy is the ability to read, write, and use arithmetic. By expanding this definition in OECD countries, the meaning of literacy is the ability to access knowledge through technology and the ability to assess complex contexts [8]. To sum up we can say literacy as ability to read any information, to write any idea, and use arithmetic to solve problems in complex contexts.

One part of literacy is mathematical literacy, that define by PISA as the capacity to formulate, employ and interpret mathematics in variety of contexts [5]. It not only includes the ability how to use mathematics, but also reasoning mathematically and use mathematics as a tool to describe, explain, and predict phenomena [5]. Other definition also described by NCTM, i.e. The ability to read, listen, think creatively, and communicate about problem situations, mathematical representations, and the validation of solutions will help students to develop and deepen their understanding of mathematics [11]. These two definitions guide us to say that mathematical literacy is the ability to use the deepen understanding of mathematics in various contexts. In the simple ways to understand how to practice mathematical literacy, see figure below.

PISA test is one of standardized test about mathematical literacy that hold every three years, in PISA student performance in mathematics is assessed through questions related to processes, contents, and contexts. Firstly, Processes in PISA is defined into formulating situations mathematically, using mathematics knowledges, and interpreting the mathematical results. In the other word, it includes the ability of students to change a problem in real world into mathematics world, and solve it in mathematics, and send it again to real world. Secondly, contents are divided into four categories, these are quantity, shape and space, change and relationships, and uncertainty. Quantity is about number sense and it forces the students to understand the measurements. Shape and space is not only about geometry, but also physical and visual aspects for instance pattern, positions, and orientations. And change and relationships, and uncertainty are about using variable and statistics and probability, respectively. Lastly, contexts i.e. the setting of student worlds in which the problems are placed. Is it in personal, societal, educational, or scientific?

Indonesia is one of OECD countries, so Indonesia should accommodate mathematical literacy in it curricula. Indonesian government has launched “Gerakan Literasi Sekolah (GLS)” (School Literacy Movement) as all of efforts that involve all of school society (teachers, students, and parents) and general society as part of educational ecosystem [10]. As a part of literacy, mathematical literacy should be involved in GLS programme at least in classroom activity such that mathematical literacy being the standard of classroom activities, exercises, and tests. So, we need to know teacher basic knowledges about mathematical literacy. This paper discusses about junior high school mathematics teachers in Pasaman ability in solving problem base on mathematical literacy, especially PISA or PISA-like problems.
3. Method
In this paper, case study was used to junior high school mathematics teachers. The data were collected through test and semi-structural interview about mathematical literacy. To make us easier in collecting data, we chose teachers from the same regency, in this case we chose Pasaman regency. We used 24 junior high school mathematics teachers in Pasaman as our sample.

The mathematical literacy test contained 10 problems which were adopted from PISA problems, Indonesian Mathematical Literacy Contest and some PISA-like problems from several researches [1,2,7,9]. These ten problems were chosen such that all of PISA contents include in the test. These are 3 quantity problems (in three different level those are level 1, 2, and 4), 2 uncertainty problems (level 4 and level 5), 3 space and shape problems (in three different level those are level 1, 3, and 4), and 2 change and relationship problems (both level 4). We provided around 10 minutes for each problem, so the teachers were asked to solve the problems in 100 minutes.

4. Results and Discussion
In this section, analysis of data that was collected is discussed. Generally, the score that has been achieved by teacher around 40 until 80 (scale 100) and from information that has resulted through semi-structural interview, the teachers did not really know about mathematical literacy, they only guessed its sense.

First of all, descriptive statistic of the result is presented as shown in the table below.

| Table 2. Descriptive statistic of Teacher Performance in Solving PISA and PISA-like Problems |
|---------------------------------------------|
| Min | Max | Average | Median | St. Deviation |
| 40  | 80  | 60.8    | 59     | 12.3          |

Based on table 2, there were still some teachers that were scored lower than 50 and no one were scored more than 80. Most of them has score around 50 and 70 as the deviation standard is 12.3.

Now, the deeper discussion about teacher response is presented in four category of PISA content i.e. quantity, shape and space, change and relationship, and uncertainty. It is shown the average score and how the teachers answered the problems.

Firstly, quantity is about number sense and how to use it in various context. Three problems were provided for this category, two of them were low level problems i.e. level 1, and 2. For the low levels problem, almost all of teachers answered it perfectly, but for one other problem that was the level 4, average score of teachers is only 2.4 (scale 10) that was divided into two sub problems in which the scores are 1.9 (scale 5) and only 0.5 (scale 5), since this item separate into two problems. The example of wrong response of the teacher is shown on the figure below.

In Figure 2, it is the answer from respondent for the problems change second to minute. The respondent divided the given 949 seconds with 3600, in fact it should be divided by 60. Others response, the respondent assumed that it is 9 minutes and 49 second this information is not given in the problems (literacy problems). And most of respondent gave the blank response. Meanwhile, in figure 3, it is the answer for problem about if one part of 4-cross road has 949 second for red light, how long green light in others part of the 4-cross road? For this problem, there is no single respondent that can answer it. The selected answer in Figure 3 is the best response from respondent. Unfortunately, for this response the respondent did not realize that the way with red light, so it should be only three other ways that has chance to have green light. To sum up, for this red-light problem, teachers are not able to comprehend the number sense in the context.
For cars $\frac{949}{3600}$ minutes $= 0.246$ minutes

By the same width of the roads, the green-light on others directions turn on in $\frac{16}{4} = \pm 4$ minutes

Figure 2. Selected Answer 1

Figure 3. Selected Answer 2

Secondly, for uncertainty problems, the teachers were given two problems in level 4 and level 5. For the first item is about “Faulty Players” that is a PISA 2012 item. This problem is divided into three items, for the first item is true or false questions in three sub-items, unfortunately no correct response for this first question because no correct response for second sub-items for others sub-items more than 80% respondents gave the correct responses. The second sub-item problem is about “if in 2000 audio players with 5% of them is faulty, then in each batch of 100 video players made, exactly 5 will be faulty”. All of respondents answered this sub-item by true. It means that all respondents have misunderstanding that 5% is an expected value, and is not an exact value. For other items in “Faulty Players”, more than 60% respondents gave correct answers, while others did not answer it.

For the second problems in uncertainty is about “Voting and Destinations”, this problem is divided into two items. The first problem is about count the numbers of voters for each destination, but the respondents assumed it as the set operations problems. After an interview, respondents gave such response because the problem just like set problem, so the respondent failed in comprehend the content of the problems. The problem and the chosen sample response are given in the figure below.

Problems: Trip Destinations

In 30 students, 4 students only choose Lawang Sewu, 8 students only choose Kebun Raya Penggoran, and 4 students only choose Kota Lama Semarang. There are 8 students that choose Lawang Sewun and Kebun Raya Penggoran, and remaining of students choose Lawang Sewu and Kota Lama Semarang. From this information, which are two destinations that will be chosen?

Translation:

A: Lawang Sewu = 4
B: Kebun Raya = 8
C: Kota lama = 4
Lawang Sewu-Kebun Raya = 8
Remaining = Lawang Sewu – Semarang
Sum = 16 + 8 =24
Remaining = 6
Lawang Sewu = 18
Tour destination that will be visited is Lawang Sewu.

Figure 4. Problem and Selected Answer 3
For this item, most of response is correct, but there is unneeded Venn diagram in the answer sheet as given in the sample answer above. The second problem is about choosing the cheapest transportations with time as constraint. Only 17% of respondent gave the correct response, while others only focus on the time they forgot to choose the cheapest way. They failed to see all possibility that is one of mathematical literacy needed.

Thirdly, for shape and space problems, from three problems, two of them are easy for the teachers i.e. for level 1 all of respondents gave correct answers and for level 3 problems more than 65% teachers has correct responses. For the level 3 problems teachers lose in reasoning and communicating their answered, they just assumed some that is not stated in the problems. When they are asked that “is the statement is correct?”, they just process the questions with the logical “if the statement is correct, is the requirement is satisfied?”. It is obviously a missing concept, because “p → q” does not mean “q ⇒ p”, to see the mistaken loot at Figure 5(a) below.

Problems: Inheritance Division
Pak Bondan bequeath his inheritance field that is in a hill side with total area 216 m² to three of his son, as shown in the figure.

Problem: in your opinion, is the inheritance division equitable? State your reason!

Translation:
In my opinion the inheritance division is fair. Because \( \frac{216}{3} = 72 \text{ m}^2 \). So, each of son get 72 m². In each \( \Delta \), its base is 8 m. So
\[
L_\Delta = \frac{a \times t}{2} = 72 \\
8 \times \frac{t}{2} = 72 \\
t = 18 \text{ m}
\]
The same, ech son have \( t = 18 \text{ m} \) and its base 8m. In triangle \( a = 24, L = 216 \)
\[
L_\Delta = \frac{a \times t}{2} = 216 \\
24 \times \frac{t}{2} = 216 \\
t = 18 \text{ m}
\]

(a)

Translation:
The inheritance division that is given by Pak Bondan
\[
L_\Delta = \frac{a \times t}{2} = 216 \\
24 \times \frac{t}{2} = 216 \\
t = \frac{216}{12} = 18 \text{ m}
\]
Because of \( t_1 = t_2 = t_3 \)
\( L_1 = L_2 = L_3 \)
Each of son get the same area that is 72 m²

(b)

Figure 5. Problem and Selected Answer 4, (a) is an incorrect response, (b) is a correct response.
Different with the answer in Figure 5(a), in Figure 5(b), the respondents show by picture that three of those triangle, each has the same height and then he counts it.

For level 4 problem in shape and space is about “Container Stack”, the respondents are given a picture of container pile and they must count the number of container in the pile. For these problem most of respondent only count it one by one and do not show their method, 35% of respondent success in count it while others failed. The example of best response by respondents is given in the figure below.

**Problem: Container Pile**

In the figure, how many containers are in the container pile? Explain the method that you use to count it!

![Image of container pile]

**Translation:**

The number of containers that is known in the pile is:

\[
\begin{align*}
I : & \quad 4 + 2 + 1 + 2 = 9 \\
II : & \quad 1 + 2 + 2 = 5 \\
III : & \quad 1 + 1 + 1 + 2 = 5 \\
IV : & \quad 2 + 1 + 3 = 6 \\
\end{align*}
\]

So, the number of container in the container pile is 25.

**Figure 6. Problem and Selected Answer 6**

In Figure 6, the respondent state clearly how to count the number of container. So the answer in the figure has the perfect mark.

Lastly is for change and relationships problems that contains two level 4 problem. For the first problem, it is about pattern as we know it is one of material in junior high school mathematics. There are so many patterns that is appears in the book for instance triangle numbers, square numbers, e.t.c. and the problem present in the same ways with the problems in the books. In this problem, there are two pattern that should be found. Those are linear just like an arithmetic series and quadratic pattern just like quadratic numbers. For the last comment to this problem is this problem is answered correctly by 80% of respondent.

Differently, the other problem is provided in the real context but also about pattern. For this problem less than 40% respondents that answer it correctly. This problem should be easier than the first one because the pattern only in linear and repeated form, but the result says “no”. May be, it is caused by the problem is presented in different ways with the fashion of problems that has been solve by the respondents before. So, they do not realize that it only linear and repeated series. Now we need to see how the respondents answered this problem. In the figure below the selected correct and incorrect answer is given.
Problem: Monas

Each Saturday night at 19.00 to 20.00, the water fountain in Monas hall is simulated. Each water fountain has their own pattern as shown in the figure bellow

Spraying the water

Stop Spraying

Times (minute)

In total, how long the water fountain sprays the water during the simulation times? Explain your answer!

Translation:
The time for water fountain to spray the water during simulation time is 5 minutes. Because of the times that is provided is 13 minutes and stop to spray 8 minutes, then \(13 - 8 = 5\) minutes.

(a) Translation:

19.00 – 20.00 = 1 hour = 60 minutes.
Base on the picture, the time for water fountain to spray the water during the simulation time is;

\[
\frac{60}{5} = 12 \text{ times} \times 2 \text{ minutes} = 24 \text{ minutes}
\]

(b)

Figure 7. Problem and Selected Answer 7 (a) is incorrect answer, and (b) is correct answer.

The Figure 7(a) is the selected incorrect response for the problem in the figure. The respondent by this answer cannot catch that the simulation time is one hour, he only counts the spraying time in the figure such that they cannot give the correct response. And, in Figure 7(b), the respondents state the answer correctly, but he did not give his reason and there is a mistaken in communicate his idea. Because he just wrote \(\frac{60}{5} = 12 \text{ times} \times 2 \text{ minutes} = 24 \text{ minutes}\), all part of this equations is incorrect, but we just try to understand his understanding.

We have discussed the detail of teacher performance in mathematical literacy base problems. By this test, some teachers failed to solve the level 4 or above problems. Sometimes they cannot catch the context, that cause a misunderstanding in answer the problems. To get the main problems of the teachers to answers we did a semi-structural interview to the teachers.

By the interview, we got some information from the teacher about mathematical literacy. Firstly, around 25% of respondents do not have enough information to understand what is mathematical literacy. Secondly, most of teacher do not know about mathematics literacy base problems. When we asked teacher to create the mathematical literacy base problems, they only give the usual application problems. For instance, “Pak Budi has a field in form of square with length side 12 m ...”. By this the respondents just think that mathematical literacy is like applications problems. And when we ask the
teacher about PISA, most of them has hear about it, but they never know about kind of PISA problems, and also they do not know about detail of PISA.

By this interview, we predict that why some teachers failed in solving PISA and PISA-like problems, especially for level 4 or above problems, it only because they do not accustomed this kind of problems.

5. Conclusion and Further Remarks
This study reports the ability of junior high school mathematics teachers in solving mathematical literacy base problems (PISA and PISA-like problems). As the case of Pasaman teachers, Some of them do not really know about mathematical literacy or PISA, some of them only hear about it. By the test results, in average, the teachers get grade 3 (scale 4) to the test. Around 25% of the teachers that is a respondent still hard in communicate their idea as in mathematical literacy, an individual has to reasoning their idea. By this result, we need to introduce and make mathematical literacy as the teacher habits through seminar, publications, books, e.t.c.. Because of teacher is the main factor that determine the student performance, we need more research in searching factor that is causing teacher abilities or how to improve teachers ability, the design of learning, and others.

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