Mathematical Literacy of Male and Female Students in Solving PISA Problem by “Shape and Space” Content

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Abstract. This is a descriptive research which aims to describe mathematical literacy of male and female students by solving PISA problem. Mathematical problems are not only related to calculations, but how our ability to apply mathematical knowledge to solve problems in daily life. The importance of mathematical literacy can be seen from the PISA. The content of this research is shape and space content. Determination of this mathematical level is corresponding by some indicators which has been developed. It has three levels that consist of low level, medium level and high level. It has been adapted with 6 indicators of mathematical literacy of PISA. The result of this research is male students reach low level 43.75%, medium level 37.5% and high level 18.75%. While, female students reach low level 11.11%, and medium level 88.89%.

1. Introduction

Education is one of the most important element in forming the next generation of the nation. Education is organized regularly, systemically and follows clear rules to achieve national education goals [1]. Every level of education, mathematics is one of the compulsory subjects that students take because Mathematics is science that aims to develop thinking skills [2]. Mathematical problems are not only related to calculations, but how our ability to apply mathematical knowledge to solve problems in daily life. Besides mathematics as a science, mathematics also functions as a mindset [3]. Mathematical literacy is very necessary and is one of the keys to overcome these problems. A mathematical literate person can estimate, interpret data both numerically, graphically and geometrically, solve daily life problems and use mathematics as a communication tool. Mathematical literacy is the ability possessed by students in assembling knowledge, formulating, solving and interpreting problems based on reason by using existing concepts and facts and through appropriate procedures [4]. The importance of mathematical literacy can be seen from the Program for International Students Assessment (PISA) conducted by the Organization for Economic Cooperation and Development (OECD) to assess the extent of knowledge and skills of 15-year-old students who are used as one of the references of development mathematical knowledge in several countries.

Based on the PISA study, Indonesian students' mathematical literacy skills are still below the OECD average. The international average score for mathematical literacy skills is 500 (level 3), while the
average score of Indonesian students' mathematical literacy abilities is 375 (level 1) [5]. Based on the 2015 PISA results, the average score that Indonesian students is 386, but this score is still below the International average score set by the OECD. In 3 years Indonesian's ranking is still very low, this shows that Indonesian students' mathematical literacy abilities have not met the standards set by the OECD. The ability of male and female students has a difference when viewed from the score obtained. The 2015 PISA average score for male students were 385, while female students were 387. This shows a difference in the results of literacy skills of male and female students. According to the 2012 PISA Survey, Indonesian students were still weak in completing shape and space content, most students were only able to reach level 3 and some of students reach level 4 and 5, even no students were able to reach level 6 [6]. This study focused on knowing the literacy skills of male and female students in shape and space content with the aim of increasing the ability of students' level of literacy, especially shape and space content.

2. Method

Data collection was obtained by conducting PISA test questions and interviews. The PISA test was conducted in X MIPA 8 class with 34 respondents consisting of 16 male students and 18 female students. The answers to the students are analyzed to determine the fulfillment of indicators at each level achieved by students. The indicators used in this study refer to the indicators of the level of PISA mathematical literacy abilities that can be seen in Table 1 below.

| Level | Indicator of Mathematical Literacy Ability |
|-------|--------------------------------------------|
| 1     | Answering questions on problem with all available information. Identify information based on instructions Perform calculations according to the strategy used. |
| 2     | Gather facts / information from existing contexts Choose a problem solving strategy from the information on the question Work on problems using basic algorithms and formulas to solve problems. Conclude the results of the problems given |
| 3     | Carry out clear procedures in solving problems Choose and use problem solving strategies Use different information based representations Describe the results and their reasons |
| 4     | Work on problems with certain steps and methods that involve assumptions in the given context. Use information in existing contexts Use skills and knowledge in carrying out calculations Give conclusions and reasons based on the formula you have |
| 5     | Work with models in identifying problems from complex situations Choose and use strategies to solve problems Using his thoughts and reasoning in carrying out calculations Describe the results of the formulation and the reasons they have |
| 6     | Make concepts and define problem solving strategies from complex situations. Translating information from problems given Using understanding in symbol mastery, mathematical operations in performing calculations Give conclusions and reasons for the results of the formulation. |
The indicators in Table 1 are used as a reference for analyzing student answers which are then conducted based on the results of student answers with the following criteria. If students are able to fulfill all indicators at level one to the highest level that is fulfilled, then the level of students' mathematical literacy skills is the highest level for which indicators are met.

1. If students are able to fulfill some indicators (at least 2 indicators) at the highest level achieved, then the student will be interviewed about that level. Based on the results of interviews students are able to meet all indicators at that level, then the level of students' mathematical literacy skills is at the highest level achieved. If not, then the level of students' mathematical literacy skills is at 1 level before.

2. If students are able to fulfill some indicators at a certain level, but cannot meet the indicators at a lower level, students will be interviewed about the level for which indicators are not met. If based on the results of interviews students are able to meet all indicators at that level, then the level of students' mathematical literacy skills is at the highest level achieved. If not, it will be retested.

The subject is taken for interviews using the snowball throwing method, which is taking random subjects. This interview aims to ascertain the level of mathematical literacy skills of male and female students. In this study, interviews will be conducted if they meet the following conditions:

1. When students are only able to fulfill some indicators (at least 2 indicators) at each level of mathematical literacy, they feel that students are able to reach that level.

2. When students are able to meet indicators at a certain level, but are unable to meet the indicators below, for example students are able to meet indicators on level 3 but cannot meet indicators on level 2.

The next step is to triangulate the researcher to check the validity of the data obtained. This triangulation by choosing 1 other researcher / investigator who conducts research similar to different regions and subjects. The investigator is tasked with correcting the results of the analysis from the researcher. In this triangulation, the researcher gave a sheet of answers from 34 students, interview results and investigator triangulation sheets, then compared with the results of the researchers. If you find differences in the results of analysis from researchers and investigators, a discussion will be conducted to find the same view so that a conclusion can be drawn at each level of PISA.

### 3. Result and Discussion

Based on the data analysis conducted, it shows that there are differences in the level of mathematical literacy skills of male students and female students of X MIPA 8. The data obtained is classified into the percentage of each level that can be achieved by 16 male students and 18 female students. Students who are able to reach the highest level achieved, then the level below is able to be filled with students. The following is the level of mathematical literacy skills of 16 male students in completing the PISA questions in Shape and Space content based on the test results and interview results can be seen in Table 2.

| Percentage  | Number Of Students | Literacy Level Achieved |
|-------------|--------------------|-------------------------|
| 43.75%      | 7                  | Level 2                 |
| 37.5%       | 6                  | Level 3                 |
| 18.75%      | 3                  | Level 5                 |

The level of mathematical literacy skills of 18 female students in completing PISA questions in Shape and Space content based on the results of tests and interviews can be seen in Table 3 below.
Based on the table above, it was found that the achievement of the level of mathematical literacy of male students was better than female students when viewed from the percentage of achievement of mathematical literacy. Male students are able to reach level 2, level 3 to level 5, while female students are able to reach level 2 and level 3 in their mathematical literacy skills. From these percentages, there are differences in their level of achievement where female students are only able to level 3, while some male students are able to reach level 5. Based on the results of tests and interviews, students who are at level 5, they are able to do the questions correctly, able to compare and evaluate strategies that are used correctly, able to describe the reasons and conclusions from the questions given. If seen from the tendency of each male and female student in working on the PISA problem, it was found that male students were able to identify problems, choose problem solving strategies, and were able to do the right calculations but they were more likely not to write conclusions and reasons for their formulation. The same is true for female students, they are more likely not to write conclusions and reasons for each level they can achieve for the Students' Mathematical Literacy Ability. The achievement of each level in male and female students is as follows.

### 3.1. Male's Students Mathematical Literacy Ability

Based on the observation, it was obtained the results of male students' literacy skills in class X MIPA 8 based on the fulfillment of indicators at each level of mathematical literacy abilities achieved by female students are as follows:

#### 3.1.1. Level 1 Mathematical Literacy

Male students are able to answer questions such as the method used by SL3. The first indicator, all students can answer the questions with the correct steps of the available information, namely the students first determine the radius of the Ferris wheel then add the distance P to the surface of the river. Based on this explanation it was found that all male students were able to matched the first indicator at level 1.

The second indicator, male students are able to identify the wheel diameter of 140 meters, the distance of point P to the river surface of 10 meters, and the maximum height of the wheel to the surface of the river 150 meters. The question is the distance from point M to the river surface. Based on this, it shows that all male students are able to matched the second indicator at level 1.

The third indicator, male students were able to find the radius of the wheel, which was 70 meters, then added the distance from point P to the surface of the river, which was 10 meters so that it obtained 80 meters as the distance of point M to the surface of the river.

#### 3.1.2. Level 2 Mathematical Literacy

Some male students are able to solve problems in problem number 2 like the method used by SL3. On the first indicator, students are able to write down the height of the 140-meter ship's kite screen, the kite string angle of the ship 450 and the question is the length of the ship's kite screen. Based on the explanation above it was found that all male students had fulfilled the first indicator at level 2.

In the second indicator, students are able to transmit what is known to the problem by using a sine formula in determining the length of the rope. From the 16 male students, there were 4 students who used sine formulas and side comparison concepts in right triangles in their calculations. This means that students have been able to choose relevant information in determining the completion strategy so that all male students have fulfilled the second indicator at level 2.
In the third indicator, as many as 15 male students were able to answer questions with correct and coherent steps. But there is one student (SL16) who made a mistake in the calculation.

In the fourth indicator, students are able to write conclusions from the results of the completion they obtained. Of the 16 male students who tried to work, there were 6 students who did not write their conclusions (SL2, SL4, SL5, SL7, SL12, SL13) and 1 student (SL16) by writing the wrong conclusion.

3.1.3. Level 3 Mathematical Literacy

Some students are able to solve problem number 3 by using the same method as SL3. On the first indicator, 13 students tried to work, there were 6 students who answered correctly and 2 students (SL7, SL9) were wrong in calculating but the two students met two indicators at this level.

The second indicator, students have been able to choose a strategy in answering the question, namely using the rectangular area formula because the roof of the building is rectangular. From the 13 male students who tried to work, there were 9 students who met the second indicator at level 3.

The third indicator, 14 male students who tried to answer, there were 9 students who were able to use information in determining the width of the roof. This shows that 9 male students have fulfilled the third indicator at level 3.

The fourth indicator, students are able to deduce the results of their formulation and reasons. From the 14 male students who tried to answer, only 6 students (SL1, SL2, SL7, SL4, SL12, SL13) did not write conclusions and 1 student (SL9) wrote the wrong conclusion. But the seven students (SL1, SL2, SL7, SL4, SL12, SL9, and SL13) have fulfilled the minimum indicators for interviews. Therefore, interviews were carried out by the seven students to find out the fulfillment of the fourth indicator. The following is one of the students' answers and interview quotes that do not write conclusions from the results of their work.

3.1.4. Level 4 Mathematical Literacy

At this level, only 3 students were able to answer correctly. Based on the first indicator, 11 male students who tried to work, only 3 students answered correctly, namely finding the length of HN and NB to find the distance from B to H. Therefore, only 3 students were able to match the 1 at level 4.

The second indicator, students are able to write down what is known, namely all the edges on the 12-meter house roof model and what is asked is the distance from point H to B. From the 11 male students who tried to work, there were 6 students who were able to write what known and asked questions. Based on this, there are 6 students who matched the second indicator at level 4.

The third indicator, 11 students tried to answer, only 3 students were able to answer correctly. Therefore, only 3 male students are able to match the third indicator at level 4.

The fourth indicator, 3 students (SL3, SL4, SL13) did not write conclusions from the results of their work. Therefore, it is necessary to conduct interviews with the three students to find out the achievement of the fourth indicator at this level.

3.1.5. Level 5 Mathematical Literacy

At this level there are 3 students who are able to answer correctly as the method used by students does not answer and 7 students answer but not matched the indicator. Based on the first indicator, students are able to work with a model in identifying problems from a given problem. This indicator is expected to enable students to identify problems given by writing down what is known and asked about the problem. Based on the students' answers, the thing that is known in question number 5a is the height of the water tank and the speed of the water and the time needed to fill the full tank. From the 10 male students who tried to answer, there were 8 students who wrote down the questions and asked them correctly. Therefore, only 8 students matched the first indicator at level 5.

The second indicator, students are able to solve problem number 5a is to determine the volume of water that is accommodated to add the volume of the tube with twice the volume of the large cone then reduced by the volume of the small cone. After finding the volume of water that is accommodated, it will get the time needed to fill the water to the full by dividing the volume with the average speed of the incoming water to get 2322 seconds. From the 10 male students who tried to work on it, there were
3 students who matched the second indicator, so that only 3 students matched the second indicator at level 5.
The third indicator, students are able to cover the volume of water collected is 2322.3 dm$^3$ and they change the unit volume from m$^3$ to dm$^3$, then they divided by 1 liter, the results are 2322 seconds. From the 16 male students, only 3 students were able to matched the third indicator at level 5.

3.1.6. Level 6 Mathematical Literacy
The first indicator is at level 6, students are able to determine the volume of water in the tank that will come out from the faucet, then determining the difference from the volume of water entering every second with the volume of water coming out in every second. The next step is dividing the volume of tank water that comes out with the result of the difference between the volume of water that enters in every second with the volume of water coming out in every second. Based on the observation, none of the male students answered the questions in number 5b so that it can be said that all male students did not matched the first indicator at level 6.
The second indicator, students are able to write down the problem number 5b is the speed of the incoming water, the speed of the water coming out, and the faucet is at the bottom of the tubular tank, and the question is the time needed for the speed of the water coming out of the faucet. Of the 16 male students, none of them wrote down what was known and asked about the question so that all male students did not matched the second indicator at level 6.
The third indicator, using understanding in mastering symbols, mathematical operations in calculating the strategies used. The answer to problem number 5b shows that the difference between the volume entering and leaving every second is 1 liter / second, the volume of the water tank coming out of the tap is 1,932 m$^3$ so the time obtained is 1932 seconds. However, all male students did not answer question number 5b so that all students did not matched the third indicator at level 6.
The fourth indicator is that students are able to provide conclusions from the results of their formulation and reasons. However, 16 male students did not try to answer questions so they were unable to matched the fourth indicator at level 6.

3.2. Female's Students Mathematical Literacy Ability
Based on the observation, it was obtained the results of 18 female students' literacy skills in class X MIPA 8 based on the fulfillment of indicators at each level of mathematical literacy abilities achieved by female students which will be explained as follows:

3.2.1. Level 1 Mathematical Literacy
All female students are able to answer questions correctly as the method used by SP11. On the first indicator, all female students can answer with the correct completion steps of all available information namely students determine the radius of the wheel first and then add the wheel radius of the wheel with the distance of point P to the surface of the river so that the distance from the point M k the surface of the river.
The second indicator, students are able to identify the wheel diameter is 140 meters, the distance of point P to the river surface is 10 meters, and the maximum height of the wheel to the surface of the river is 150 meters, and what the question is the distance from point M to the surface of the river. Based on this explanation, shows that all female students are able to matched the second indicator at level 1.
The third indicator, all female students are able to do the correct calculation of the problem given by finding the radius of the wheel, which is 70 meters, then adding the distance from point P to the surface of the river, which is 10 meters so that it gets 80 meters as the distance of point M to the surface of the river. From this calculation, students have done the calculation according to the strategy used so that it can be said that all female students are able to fulfill the third indicator at level 1. But of 8 female students there are 3 students (SP3, SP5, SP7) who do not write the results from their work.

3.2.2. Level 2 Mathematical Literacy
At level 2, there are 13 female students able to solve problems in problem number 2 like the method used by SP10, while 5 students use different methods but with the correct steps and final results. In the
first indicator, students are able to determine what is known and asked about the question. Based on the students' answers, it was found that out of 18 female students who tried to work, 17 students were able to determine what was known and asked in the problem and there was 1 student (SP3) who did not write down what was known in the problem. Students interpreted what was known was the height of the ship's 140 meter screen, the angle of the kite rope to the ship 45° and was asked about the length of the kite screen. Based on students' answers, there was 1 student (SP3) who did not write down the questions and asked questions so that an interview was needed to find out the achievement of the first indicator at this level because the students fulfilled two indicators at level 3.

The second indicator, students use sine formulas and side comparison concepts in right triangles in their calculations. This shows that students have been able to choose information in determining the settlement strategy so that all female students have fulfilled the second indicator at level 2.

The third indicator, a total of 17 female students were able to answer questions with correct and coherent steps. But there is one student (SP18) who made a mistake in calculating in the form of making a mistake in the multiplication process in the sine formula that he uses so that the final answer is wrong.

3.2.3. Level 3 Mathematical Literacy
Some students are able to solve problem number 3 by using the method used with SP1. The first indicator, students answer by determining the width of the roof first and then determine the total area of the warehouse roof. From 18 students who tried to answer, there were 14 students who answered with the right steps, and 2 students (SP9, SP15) made incorrect calculations. Based on the student answer SP15, SP9 and SP15 have the same answer so that the location of the error in both students is similar, that is the two students are wrong in calculating the width of the roof. The error lies when simplifying $\sqrt{7,25}$ to $5\sqrt{29}$ so the end result is wrong.

The second indicator, students are able to choose a strategy that is to determine the area of the roof of the two roofs of the building using a rectangular formula because the roof used is rectangular. This shows that students have been able to choose what strategy is used to answer the question. From 18 female students there are 16 students who matched the second indicator at level 3.

The third indicator, students inform differently by determining the roof width first in determining the total roof area. The roof width is obtained from the information contained in the problem, namely the distance of the roof from the wall and the height of the roof from the wall. Based on student answers, from the 18 female students there were 16 students who were able to find the width of the roof correctly. This shows that only 16 students were able to matched the third indicator at level 3. From the 18 female students, there were 16 students who were able to matched the third indicator at level 3.

The Fourth indicator, students conclude the results of their formulation. From the 18 female students, only 8 students (SP2, SP3, SP4, SP12, SP6, SP7, SP9, SP15) did not make conclusions.

3.2.4. Level 4 Mathematical Literacy
At this level, there are 10 students who try to answer questions at this level. The first indicator, 10 students who tried to work, none of them were able to fulfill this first indicator because the steps they used were not appropriate in solving the problem. The steps in solving the problem is to determine the length of the HN that can be obtained from the length of the DH with DN by using the concept of phytagoras, the length of NB can be obtained from the difference from the diagonal BD with DN so that the distance between B and H can be obtained using the concept phytagoras. Based on this, it was found that all female students did not matched the first indicator at level 4.

The second indicator, students are able to write down what is known on the problem is the length of all edges, while what is asked is the distance point B to H. From 12 students who tried to work on this second indicator, only 8 students wrote down the questions and asked about the questions. Based on this, From 18 female students, only 8 students matched the second indicator at level 4.

The third indicator, students are able to use their skills and knowledge in calculating the strategies used by writing down the steps students use is not appropriate to answer these questions so the results are
wrong. Based on this, From 10 students who tried to answer, none of the female students matched the third indicator at level 4. The fourth indicator, students are able to conclude the results of their completion based on the formula they have along with the reasons by writing the results of the correct conclusions. From 10 students who tried to work, no one wrote the correct final result at number 4. Therefore, all female students were unable to matched the fourth indicator at level 4.

3.2.5. Level 5 Mathematical Literacy
Based on students' answers, there were 9 students who tried to answer questions at this level. But 9 students who tried to answer, none of them were able to fulfill the indicator. Based on the first indicator, work with the model in identifying problems from the problems provided by writing down what is known and asked about the problem. Based on students' answers, the thing that is known in problem number 5a is the height of the water tank with the lid, the speed of the water, and what is asked is the time needed to fill the tank to the full. Based on this, out of 9 female students who tried to answer, there were 9 students who wrote down the questions and asked questions correctly. Therefore, out of 18 female students, only 9 students matched the first indicator at level 5.

The second indicator, students are able to choose and use strategies to solve problems from the problems given. This indicator is intended for students to be able to find strategies to solve these problems by writing down the correct resolution steps. However, 4 students answered the question by dividing the water level in the water tank with the average speed of water entering. Then the other 4 students answered by adding up the volume of the tube by two times the large cone volume so that the volume of water collected was collected, and the time obtained from dividing the volume of water collected at the average speed of water. But the correct steps in solving problem number 5b are determining the volume of water that is accommodated, namely adding up the volume of the tube with twice the volume of the large cone then reducing it to the volume of the small cone. Therefore, none of the 8 students who tried to work, were able to matched the second indicator at level 5.

The third indicator, students are able to use their thinking and reasoning in calculating the strategies used. Based on the students' answers, the time needed for the full water tank is 4.5, while the time needed for the full water tank is 2355 seconds. But the time needed to fill the water tank to the correct full is 2323 seconds. Based on this, none of the 9 students who tried to answer, matched the third indicator at level 5.

The fourth indicator, students are able to conclude the outcome of the formula that is owned, namely writing a conclusion from the results of their work. From 8 students who tried to work, there were no students who matched the fourth indicator at level 5.

Based on the explanation above, From 8 students who tried to work, none of them matched all indicators at level 4 so that it could be concluded that all women were unable to reach level 5.

3.2.6. Level 6 Mathematical Literacy
Based on students' answers, there were 5 students who tried to answer questions at this level. In the first indicator, the method used by students in solving the problem, it can be said that the student does not pay attention to the position of the faucet on the tank and changes in the volume of water in the tank every second. The position of the faucet and changes in water volume will determine the method in solving the problem at this level. The position of this faucet determines the volume of water coming out of the water tank, and changes in water volume are related to the time needed for the water velocity to change. The steps that can be used by students to answer questions is to determine the volume of water in the tank that will come out of the faucet, then determine the difference from the volume of water entering every second with the volume of water coming out every second. The next step is to divide the volume of tank water that comes out with the result of the difference between the volume of water that enters every second with the volume of water coming out every second. Based on this explanation, from 5 students who tried to answer, none of them matched the first indicator at level 6.
The second indicator, students can write down what is known and asked about the question. The thing that is known in problem number 5b is the speed of the incoming water, the speed of the water coming out and the tap is at the bottom of the shaped tank.

4. Conclusion and Suggestion

Based on the results of the tests analysis and interviews, the achievement of mathematical literacy skills of male and female students of the 10th class, case study: (senior high school in Jember) in solving the PISA problem the shape and space content can be summarized as follows.

a. The percentage of mathematics literacy skills of male students at level 2 is 43.75% or as many as 7 students. The percentage of mathematics literacy skills of boys at level 3 is 37.5% or as many as 6 students and the percentage of mathematics literacy skills at level 5 is 18.75% or as many as 3 students.

b. The percentage of mathematics literacy ability of female students at level 2 is 11.11% or as many as 2 students and the percentage of mathematics literacy skills of female students at level 3 is 88.89% or as many as 16 students.

Based on the results of research on the mathematics literacy skills of male and female students of the 10th class, case study: (senior high school in Jember) in completing the PISA problem shape and space content, then for the sake of usefulness of this research are given some suggestions as follows:

a. Students should often work on questions that require broader thinking and reasoning, and math literacy questions to improve students' mathematical literacy skills such as the PISA problem.

b. The teachers should more often provide exercises related to math literacy skills so that the level of student literacy can increase as students work on PISA questions.

c. Further researchers should find the right method to improve mathematical literacy skills and also finding a more efficient way of determining the level of students’ mathematical literacy skills. In conducting interviews, it should be done on the same day as the test so that students still remember the answers that have been done.

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