Student’s mathematical literacy ability on PISA’s space and shape task

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Abstract. The aim of this research is to describe the mathematical literacy ability of students based on space and shape problems PISA. This research is a qualitative descriptive research. Its subjects are three students of the 8th grade. MTs Muallimaat Muhammadiyah Yogyakarta consists of 36 students. The test technique is the only data collection instrument used by the researcher in this research. A mathematical literacy test consisting of 4 PISA questions is used there are 2 question space and shape problems and 2 question change and relationship. The research results presented in this paper are the results of the test for space and shape problems with 2 questions in level 3. For the first space and shape problem, there are 25% students who are able to answer questions and get good scores. Meanwhile, 78% of the students are able to answer questions and get scores in the second space and shape problem.

1. Introduction
PISA is the acronym of ‘Program for International Student Assessment’, organized by the OECD in conjunction with a group of other participating countries, including Indonesia, to assess the literacy skills in reading, mathematics, and science of students aged about 15 years [1]. In short, PISA addresses “the capacity of students to put mathematical knowledge into functional use in a multitude of different situations in varies, reflective and insight-based ways [2].

The literacy ability is one of the 21st century skills. The 21st century skills refer to content knowledge, literacy, and proficiency that prepare individuals to meet the challenges and opportunities of today’s world [3]. Based on the National Council of Teachers of Mathematics (NCTM), there are five competencies in mathematics learning: mathematical problem solving, mathematical communication, mathematical reasoning, mathematical connections, and mathematical representation. The capability that includes these five competencies is known as mathematical literacy ability [4]. So, Literacy skills need to grow and mature over the course of every person’s life, giving each individual the reading, writing and thinking skills needed for success in academic, workforce and personal situations.

Mathematical literacy is defined as the ability of a person to formulate, apply and interpret mathematics in various contexts, including the ability to do mathematical reasoning and use concepts, procedures, and facts to describe, explain or estimate phenomena/events [5]. Mathematics literacy as the knowledge to know and apply the basic mathematics in our daily lives [6]. According to Stacey, mathematics literacy is the student’s ability to identify and understand the role of mathematics in real life. Mathematics literacy is an issue in society that should be able to access quality public education for mathematical thinking [7].
PISA is used by governments to monitor the performance of their educational system [1]. It can also describe characteristics of the educational system, including those which may impact on whether a society is harnessing the talents of all of its people. Through operating the construct of mathematical literacy, PISA has given voice to a vision of education in order to prepare all future citizens to live productive and satisfying lives. In addition, PISA also aims to assess the extent to which students near the end of compulsory education have acquired the knowledge and skills necessary to fully participate in modern society. Assessments in PISA not only ensure whether students can reproduce knowledge, but also test how well they can extrapolate from what they have learned and apply that knowledge in unfamiliar settings, both inside and outside school [2].

Result of research conducted by PISA show that mathematical literacy of Indonesian students is very low [2]. Related to this, Mahdiansyah and Rahmawati [8] in result of their research that mathematical literacy of Indonesian students is low. Results of research conducted by Andi, Zulkardi, & Darmawijoyo [9] indicate that students’ skills in solving mathematical literacy problems is not maximum yet. Also related to this, that Indonesian student’s mathematics problem solving skill in PISA and TIMSS were not show good achievement [10]. In specific area, that mathematical literacy of Senior High School students in Yogyakarta for understanding category and process belong to very low category [11].

Indonesia students’ performance in mathematical literacy is measured by PISA. In PISA 2012 [2] Indonesia was rank declined to rank 64 of 65 the participant countries, even based on the last PISA 2015 [2] Indonesia was ranked 63 out of 69 countries. The table 1 shows the average scores and ranking of student’s mathematical literacy ability in Indonesia on PISA 2000-2015 [2]:

| Year | Indonesia Average Score | International Average Score | Indonesia Rank | Total of Countries Members |
|------|-------------------------|-----------------------------|----------------|---------------------------|
| 2000 | 367                     | 500                         | 39             | 41                        |
| 2003 | 360                     | 500                         | 38             | 40                        |
| 2006 | 391                     | 498                         | 50             | 57                        |
| 2009 | 371                     | 496                         | 61             | 65                        |
| 2012 | 375                     | 494                         | 64             | 65                        |
| 2015 | 386                     | 500                         | 63             | 69                        |

PISA data show that students who mainly use memorization strategies in their learning tend to perform worse on mathematics questions that require formulating a problem, compared with problems that ask students to use formulas or interpret results [12].

The material of the PISA test in mathematical literacy can be grouped into four group, namely (1) the quantity, (2) change and relationship, (3) uncertainty, and (4) shape and space [2]. One of the research questions that would be answered by researchers in this paper is what are the solution profiles of junior high school students in adapting PISA test for space and shape problems.

The Table 2 there are six levels in the PISA questions related to mathematical literacy of students [2].
Table 2. The six levels of mathematics proficiency in PISA 2015

| Level | Characteristics of Tasks |
|-------|--------------------------|
| 1     | Students could answer questions involving familiar contexts where all relevant information was present and the questions were clearly defined. They were able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They could perform actions that were obvious and follow immediately from the given stimuli. |
| 2     | Students can interpret and recognize situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulas, procedures or conventions to solve problems involving whole numbers. They are capable of making literal interpretations of the results. |
| 3     | Students can execute clearly described procedures, including those that require sequential decisions. Their interpretations are sufficiently sound to be a base for building a simple model or for selecting and applying simple problem-solving strategies. Students at this level can interpret and use representations based on different information sources and reason directly from them. They typically show some ability to handle percentages, fractions and decimal numbers, and to work with proportional relationships. Their solutions reflect that they have engaged in basic interpretation and reasoning. |
| 4     | Students can work effectively with explicit models for complex, concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic, linking them directly to aspects of real-world situations. Students at this level can utilize their limited range of skills and can reason with some insight, in straightforward contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments and actions. |
| 5     | Students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterizations, and insight pertaining to these situations. They begin to reflect on their work and can formulate and communicate their interpretations and reasoning. |
| 6     | Students can conceptual, generalize and utilize information based on their investigations and modelling of complex problem situations, and can use their knowledge in relatively non-standard contexts. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply this insight and understanding, along with a mastery of symbolic and formal mathematical operations and relationships, to develop new approaches and strategies for attacking novel situations. Students at this level can reflect on their actions, and can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situation. |

Many factors must be considered in the study of mathematical literacy, among other: mathematics ability, and specific intelligence, readiness of teacher and students, curriculum, and methods presented, a factor that is not less important is the gender factor [13-15]. A gender difference necessarily leads to differences in physiology and affect the psychological difference in learning. So, male and female students certainly have a lot of differences in mathematics learning [14]. Most studies has focused on comparing mathematical performance of male and female students [14, 15], in this research will describe only female student performance in mathematical literacy. One of the research questions that
would be answered by researchers in this paper was how were the mathematical description of the literacy skills solution profiles of students for the PISA’s shape and space task.

2. Research Method
The setting of this research is class VIII MTs Muallimat Muhammadiyah Yogyakarta with the number of 36 students in the 2017/2018 academic year. The 36 students have various level of mathematics ability. The research methodology used in this research is a descriptive method with qualitative approach. However, also used quantitative data with numbers and basic statistics to support arguments and findings in the discussion. The data collection technique used in this research is test technique. The test consists of 2 PISA problems for shape and space in level 3. The two used problems are as Figure 1.

3. Souvenir craftsmen will pack 600 pieces of souvenirs into a box in the shape of a cube with a length of 72 cm. The souvenirs are also in the form of a cubes, each cube with a length of 14.4 cm. How many boxes do these craftsmen need so that all their souvenirs can be packed?

Figure 1. Problem about souvenir packages

Figure 1 presents the problem about souvenir package. The students were asked to help souvenir craftsmen in determining the number of boxes needed to package the souvenir.

4. The school wants to build a 20 m x 15 m hall. On the floor of the hall, brown ceramic tiles will be installed. Therefore, the school must buy ceramics. There are various sizes of ceramics, namely 15 cm x 15 cm, 20 cm x 20 cm, and 25 cm x 25 cm. To buy ceramics, the school must buy ceramics per carton with one box containing 8 pieces of ceramic.

a. According to your opinion, which ceramic size should be purchased by the school so that the remaining ceramics can be as minimal as possible? Give an explanation of your answer!

b. How many ceramic boxes should the school buy according to the size that you think is the most appropriate? Give an explanation of your answer!

Figure 2. Problem about choosing ceramics
Figure 2 presents a problem about choosing ceramic. There are three types of ceramic with different sizes. The students were asked which size of ceramics should be purchased by the school so that the remaining ceramics can be as minimal as possible and how many ceramic boxes should the school buy according to the most appropriate size.

3. Result and Discussion
Mathematics literacy test was conducted on Tuesday, January 16, 2018 in grade VIII D. Mathematical literacy items were divided into four domains, namely the change and relationship, space and shape, quantity, and uncertainty and data. The research that would be presented in this paper were the result test for space and shape problems. Diagram percentage of average mathematics literacy skills of students to each problem as follows.

![Diagram percentage of average mathematics literacy skills of students to each problem](image)

**Figure 3.** Percentage of students who can answer the space and shape problems

Based on Figure 3, for the first space and shape problem, there are 9 of 36 students (25%) who were able to answer questions and get scores. For the second space and shape problem, 28 of 36 students or 78% were able to answer questions and get scores. However, for the first and second problems, none of the students could get maximal scores.

The results of this research are in line with the results obtained from the research which states that space and shape is a content with a mean score-average lower than change and relationship [17]. In space and shape content includes student’s ability to recognize shape, determine similarities/differences in various dimensions and forms of representation [2].

In the following section, researcher would present the solution profile of the students for the space and shape problems.

3.1 The first space and shape problem
The profile of the students for this problem is as follows:
a) There is only one student who answered correctly by getting an almost perfect score, all processes / steps for solving problems for the volume of cardboard and souvenirs are done correctly by him, but the error lies in the final step.
Figure 4. An example of the student answer of the first space and shape problem

Figure 4 shows that students can calculate the volume of the box correctly. But the students do not do the calculations correctly for the volume of souvenirs. The student also makes a mistake in calculating fractions. In the interview, a student told that she had been mistaken in writing ‘125’, that should be ‘2987’. When asked, where did these numbers come from, the students were confused to answer them. They said, 2987 from volume of souvenir 14.4cm. The students do not focus on answering questions and hurrying in the process of answering the problem.
b) There are 35 students who incorrectly answered, they wrote that the answer is 120 boxes with various calculations that are still containing many errors

Figure 5. An example of the student answer for the first space and shape problem

Figure 5 shows that students cannot process the information what is known and asked the question. The students just try multiplying the number 14.4 by a free number so that they get 172. In the interview, a student told that the answer ‘12’ is a guess.

3.2 The second space and shape problem
The profile of the students for this problem is as follows:
a) There are 23 students answered by calculating the area of the hall and area per ceramic. However, only two students get almost a perfect score. Almost all students were wrong in calculating the area of ceramic 25cm x 25cm and 15cm x 15cm. There are 20 students answered 25 x 25 = 725, there is 1 student answered 15 x 15 = 252. Meanwhile, only 1 student answered 15 x 15 = 275. There are still many students who wrote the unit area incorrectly.
Figure 6 shows that students have tried to calculate the area of each ceramic, but they made a mistake in multiplication on one of the ceramics. Students are not focused on working on this problem and the possibility of students still having difficulties in material numbers.

b) There are six students who answered and choose 20cm x 20cm ceramics and 94 ceramic boxes. The students choose this size ceramic because they only did calculations with a ceramic size of 20cm x 20cm. The mentioned ceramic size should be 25cm x 25cm ceramics and should also be calculated so that later the ceramic that will be chosen is the best ceramic.

c) There are seven students who immediately guessed/answered and wrote the answer that is choosing a ceramic measuring 20cm x 20cm, without writing down the calculation.

In this research, each student has a different level of literacy ability. Some students have also been able to solve, interpret problems and present their answers quite well. This is in agreement with research results that mathematical literacy is a person's ability to formulate, solve, and interpret problems based on the existing context [18]. The comprehension error is the most performed by the students in solving PISA problems, students cannot process the information what is known and asked the question. The results of this research reinforce the results of research which states that Indonesian students are only able to answer questions PISA level 1, 2, 3, while only some of them can solve the fourth level [19].

4. Conclusion
For the first space and shape problem, there are 1 of 36 students achieved level 3. Meanwhile, there are 2 of 36 students achieved level 3 in the second space and shape problem. For the first space and shape problem, there are 25% of the students who are able to answer questions and get scores. Meanwhile, there are 78% of the students were able to answer questions and get scores in the second space and shape problem.

5. Acknowledgement
The authors thank to Universitas Sebelas Maret and also to the teachers of MTs Muallimaat Muhammadiyah Yogyakarta who helped us in this research.

6. References
[1] Stacey K 2011 The PISA View of Mathematical Literacy in Indonesia, IndoMS Journal of Mathematics Education 2 95
[2] Andrews P 2015 Mathematics, PISA, and culture: An unpredictable relationship Journal of Educational Change 16 251 https://doi.org/10.1007/s10833-015-9248-2
[3] Ledward, B. C., and D. Hirata. 2011 An overview of 21st century skills. *Summary of 21st Century Skills for Students and Teachers, by Pacific Policy Research Center*. Honolulu: Kamehameha Schools–Research & Evaluation

[4] Maryanti E 2012 *Peningkatan Literasi Matematis Siswa Melalui Pendekan Metacognitive* (Bandung: Universitas Pendidikan Indonesia)

[5] OECD 2015 PISA 2015 Assessment Framework Key Competencies in Reading, Mathematics and Science. Paris: OECD Publishing

[6] Ojose B 2011 Mathematics Literacy: Are We Able to Put the mathematics We Learn Into Everyday use? *Journal of Mathematics Education* 4 89

[7] Brawley D S 2012 College Mathematics Literacy Workers of The Young People’s Project Chicchago: A Community of Practice *Journal of Urban Mathematics Education* 5 44

[8] Mahdiansyah and Rahmawati 2014 Literasi matematika Siswa Pendidikan Menengah: Analisis Mengunakan Desain Tes Internasional dengan Konteks Indonesia *Badan Pengembangan dan Penelitian Kemdikbud*

[9] Andi H D, Zulkardi, and Darmawijoyo 2015 Assessing Seventh Graders Mathematical Literacy in Solving PISA-Like Task *IndoMS-JME* 6 39

[10] Nindya F W and Jailani 2015 Indonesian Students Mathematics Problem Solving Skill in PISA and TIMSS *Proceeding of International Conference on Research, Implementation and Education of Mathematics and Science 2015* Universitas Negeri Yogyakarta 17-19 May 2015

[11] Rosalia H N and Ariyadi W 2017 Mathematical Literacy of Senior High School Students in Yogyakarta *Jurnal Riset Pendidikan Matematika* 4 100 [http://dx.doi.org/10.21831/jrpm.v4i1.10649](http://dx.doi.org/10.21831/jrpm.v4i1.10649)

[12] OECD 2016 Ten Questions for Mathematics Teachers … and how PISA can help answer them, PISA, Paris: OECD Publishing

[13] Nurcholif D S and Abi S 2016 Education in 21th Century: Responding to Current Issues Integrating Mathematical Literacy and Mathematics Teaching and Learning in a Mathematical Class *International Conference on Education 2016* Universitas Negeri Malang

[14] Siti L 2017 Mathematical literacy skills of students’ in term of gender differences *AIP Conference Proceedings* https://doi.org/10.1063/1.4995146

[15] Yilmazer G and Masal M 2014 The relationship between secondary school students’ arithmetic performance and their mathematical literacy *ELSEVIER* 152 619

[16] Florentina A, Regina M, and Haniek P 2017 Analisis kemampuan Literasi Matematika Kelas VIII Menurut Gender *Proceeding Seminar Nasional Etnomatematika* ISBN: 978-602-6258-07-6

[17] Hasnawati 20116 Description of Mathematics Literacy Ability of Students First Secondary School State 15 Kendari Based on Content, Context, Materials, and Process *International Journal of Education and Research* 4 201

[18] Stacey, K 2010 Mathematical an Scientific Literacy Around The World *Journal of Science and Mathematics education in Southeast Asia* 33 1

[19] Edo S I, Ilma R and Hartanto Y 2013 Investigating Secondary School Students’ Difficulties in Modelling Problems PISA-Model Level 5 and 6 *JIMS Journal* 4 41 [https://doi.org/10.22342/jme.4.1.561.41-58](https://doi.org/10.22342/jme.4.1.561.41-58)