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ANALYZING MATHEMATICAL LITERACY OF JUNIOR HIGH SCHOOL STUDENTS IN WEST SUMATRA

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Abstract

The aim of the research was to describe mathematical literacy of junior high school students in West Sumatra Indonesia. The description was focused on the competences clusters mentioned by Program for International Student Assessment (PISA), namely reproduction, connection, and reflection cluster. Based on the description, it was analyzed the factors that have influenced mathematical literacy of the students. The method used in the research was a mixing method (descriptive and qualitative). Data was collected from 188 Junior High School students who participated in Mathematical Literacy contest in West Sumatra. The results of the research show that most students only master reproduction cluster and very few of them that master reflection cluster. For each cluster, the score of most students are very low. In addition, mathematical abilities of the students are not satisfactory.

Key words: mathematical literacy, mathematical ability

INTRODUCTION

The achievements of the students of junior high school in learning mathematics, especially in the national examination, have been quite satisfactory. However, many educators do not satisfy with these results. The high achievements have not been reflected by the way students think and act in everyday life. The results were also not reflecting what the students normally achieved in daily quizzes given by their mathematics teachers (see Fauzan, 2010).

Students' understanding of mathematical concepts tends to be temporary. They often forget the basic concepts that have been studied before, when such concepts needed back on the next topic. In fact, it is often found that junior high school students do not understand the basic concepts of fractions and integers they have learned several times in the elementary school (Fauzan, 2009).

Another problem can be seen from the weakness of students in problem solving and reasoning, especially those involving higher order thinking. This can be observed from the results of some of the international studies such as *the Trends in International of Mathematics and Science Studies (TIMSS)* (see *http://nces.ed.gov/timss/).* As the TIMSS assessment framework focused on problem solving and mathematical reasoning, we can conclude that most Indonesian students are weak in both aspects of the mathematical abilities.

Similar results were found in *Program for International Student Assessment (PISA)* studies (see OECD, 2010a; OECD, 2013). The rank of Indonesian students in these studies has always been at the bottom 10%, and there was no Indonesian students that could achieve the score at the highest two levels (see Stacey, 2011). The results achieved by Indonesia were far below the average score of the counties of *Organization for Economic Co-operation and Development (OECD),* as shown in Table 1. These conditions reflect that Indonesian students

are still weak in solving math problems involving *higher order thinking.*

Table 1. The Comparison of Average Scores of Indonesia and OECD Countries at PISA Study in 2009

Country	Mean	Percentiles					
		5th	10th	25th	75th	90th	95th
Indonesia	371	260	284	324	416	462	493
OECD average	**496**	**343**	**376**	**433**	**560**	**613**	**643**
Australia	514	357	392	451	580	634	665
Finland	541	399	431	487	599	644	669
Hong Kong-China	555	390	428	492	622	673	703
Japan	529	370	407	468	595	648	677
Thailand	419	295	321	365	469	522	554

(OECD, 2010b)

PISA study aims at exploring mathematical literacy of students aged around 15 years from each participating country. Mathematical literacy is an individual's capacity to identify and understand the role of mathematics in life, as well as the use of mathematics in interpreting and solving problems of everyday life in a constructive and reflective way (de Lange, 1995; OECD, 2009a). In the Indonesian context, mathematical literacy can be defined as "melek matematika".

In PISA study, mathematical literacy includes three domains, namely *context*, *content*, and *competencies* (OECD, 2003). For competencies domain, the ability of students is divided into three clusters *reproduction*, *connection*, and *reflection.* The substance of competencies domains consists of eight mathematical abilities *mathematical thinking and reasoning, mathematical argumentation, modeling, problem posing and problem solving, representation, symbols and formalism, mathematical communication,* and *aids and tools* (OECD, 2003; 2006; 2009a).

Competencies domain tested in the PISA study is similar to the goals of mathematics curriculum in Indonesia (Depdiknas, 2006), as follows:

1. Practice how to think and reason mathematically
2. Develop a creative activity involving imagination, intuition, and discovery, by developing divergent thinking, original, curiosity, make predictions and conjecture and trial and error.
3. Develop problem-solving abilities
4. Develop the ability to convey information and ideas through discussion, charts, diagrams, maps, and diagrams in explaining the ideas.

Given the similarities, we expect that the results achieved by the Indonesian students in the PISA study would be quite good. However, some of the data described above indicates a different situation. Preliminary study conducted in West Sumatra shows that most of mathematics teachers do not familiar yet with PISA study and with math problems given in the study. When one of the problems used in PISA study given to the teachers, most of them were getting confuse.

What is more expensive, a round pizza with a diameter 30 cm and the price is Rp 30.000
or *a round pizza with a diameter 40 cm and the price is Rp 40.000? The thickness and the quality of both pizzas are the same. Explain your answer!*

We assume that none of the math teachers who do not know the formula for determining the area of a circle. However, when faced with the problem above, they come up with three different answers. This indicates that teachers have difficulty to use math in solving everyday problems. If mathematics teachers themselves lack in mathematical literacy, it is strongly suspected that the problem also occurs in students.

To reveal mathematical literacy of students of junior high schools in West Sumatra and factors that influence it, it was conducted a study with research question as follows.

1. How is mathematical literacy of junior high school students in West Sumatra?
2. What factors influence mathematical literacy of junior high school students in West Sumatra, from mathematics teachers' point of view?

The study was focused on the substance of the competency cluster and the six mathematical abilities namely representations, connections, problem solving, reasoning, and communication. These abilities refer to the theories and indicators mentioned by Ott (1993), Holmes (1995), NCTM (2000), Sumarmo (2003), Depdiknas (2004), and OECD (2003, 2006, 2009). The results of this study were expected to provide a complete and in-depth description of mathematical literacy of the junior high school students in West Sumatra and the factors that influence it.

RESEARCH METHOD

This study used descriptive method. The subjects of the study were 188 students of junior high schools in West Sumatra who have been participated in Mathematical Literacy Contest (MLC) conducted by State University of Padang on 22 of September 2012. To explore the factors that affect students' mathematical literacy, 18 mathematics teachers from participated schools were selected as resources. These teachers come from schools with a high level, medium, and low (based on the results of the national examination).

Data about mathematical literacy and mathematical ability of the students was collected through test. The test used in this study was designed by a team from 12 universities in Indonesia *(note:* MLC conducted simultaneously in 12 provinces in Indonesia). The test consisted of three clusters, namely reproduction, connections and reflection. Referring to the mathematical abilities, the test set included representations, connections, reasoning, communication, and problem solving

Factors that influence mathematical literacy of the students were investigated by giving questionnaires to mathematics teachers. Questionnaire was designed using Licker scale. Data in this study were analyzed descriptively. The results of tests would be described in three categories: high, medium, and low, while the results of the questionnaire used five categories: very poor, poor, fair, good, and very good.

RESULT AND DISCUSSION

Table 2 below presents mathematical literacy of the students on three clusters.

Table 2. Students' Mathematical Literacy Based on the Cluster

No.	Cluster	Low Level	Middle Level	High Level
1	Reproduction	19.68%	68.62%	11.70%
2	Connection	54.79%	37.23%	7.98%
3	Reflection	52.66%	26.60	20.74%
	Average	**42.38%**	**44.15%**	**13.47%**

From Table 2 we can see that most of the students have only reached the low and middle levels for the three clusters. Meanwhile, the percentage of the students who achieved the high level of scores was very low. It means that they lack of ability in applying mathematical concepts in a new situation and lack of ability in solving problems that were required higher order thinking. The results were consistent with the data from PISA studies (see OECD, 2005, 2010b; Stacey, 2011).

Similar results were found on mathematical abilities of the students, as can be seen on Table 3.

Table 3. Students' Mathematical Ability

No.	Mathematical Abilities	Low Level	Middle Level	High Level
1	Representation	16.49%	69.68%	13.83%
2	Connection	57.98%	28. 72%	13.30%
3	Reasoning	84.57%	0%	15.43%
4	Communication	29.79%	57.44%	12.77%
5	Problem Solving	40.96%	34.57%	24. 47%
	Average	**45.95%**	**38.10%**	**15.95%**

Data in Table 3 shows that mathematical abilities of most students were in low and middle category; meanwhile very view of them could achieve high level of scores. The students only showed a rather good performance in mathematical representations and communication. However, reasoning ability of most students was very weak. This finding is in line with the results of TIMSS study.

The findings above were influenced by the knowledge of mathematics teachers about PISA study and mathematical literacy as well as their ability and willingness to assess these aspects in their teaching practices, as can be seen in Table 4.

Table 4. The Factors Influenced Students' Mathematical Literacy and Abilities

No.		Percentage				
		Very Poor	**Poor**	**Fair**	**Good**	**Very Good**
1.	Teachers' knowledge about PISA and mathematical literacy	16.7	44.4	38.9	0	0
2.	Teachers' knowledge about mathematical abilities	5.5	16.7	50	27.8	0
3.	Teachers' ability in assessing mathematical literacy of the students	27.8	55.5	16.7	0	0
4.	Teachers' ability in assessing mathematical abilities of the students	5,5	27,8	50	11,1	5.5
5.	Teachers' willingness to assess mathematical literacy of the students	5.5	27.8	61.1	5.5	0
6.	Teachers' willingness to assess mathematical abilities of the students	0	16.7	66.7	16.7	0

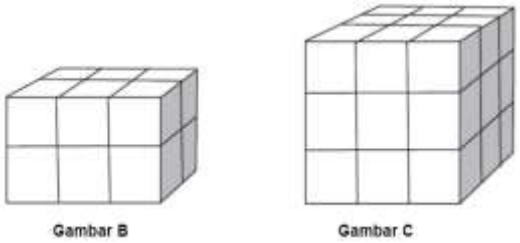
Data in Table 4 show that most of mathematics teachers, who have been surveyed, were not familiar with PISA study and mathematical literacy. Although more than a half of them willing to assess mathematical literacy and mathematical abilities of the students, but most of them lacked of ability to assess the two aspects.

The results of this study showed that mathematical literacy and mathematical abilities of the students of junior high school in West Sumatra were not well developed. Due to PISA's

cluster, it was expected that the students would achieve a good result in the reproduction cluster, because here the students were only required to apply directly mathematical knowledge that they have acquired at school. However, majority of students (nearly 90%) only achieved the score in low and middle level. Based on the analysis of the students' answers it was found that most students were not familiar with math problems in PISA's type. The following is an example of student' answer in solving an item of reproduction cluster.

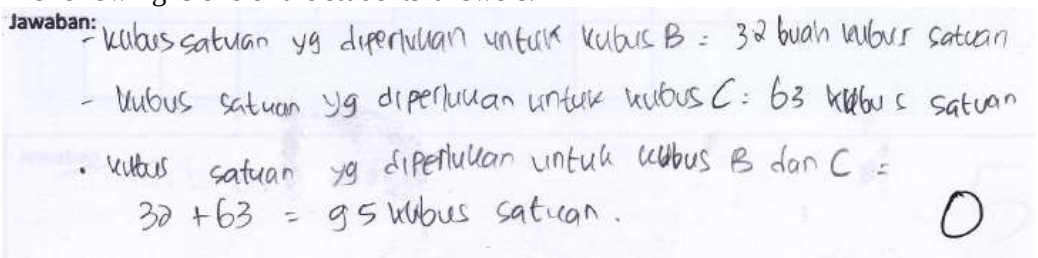
Ifa is a grade VII student who likes to make blocks using unit cubes as shown in the following figure. By using glue she built blocks consisting of eight unit cubes as shown in Figure A.

Furthermore, Ifa makes another block as shown in Figure B and C



How many unit cubes Ifa needs to make the blocks as shown in figure B and C?

The following is one of the students' answers.



The students only need a simple spatial and computation abilities to find the answers are 12 unit cubes for figure B and 27 unit cubes for figure C. However, the given answer indicates that the students lacks of spatial ability and in computation. Although there has been information that figure A was made from eight unit cubes, but students are not able to use the information to find the correct answer.

The problem above is much easier than the similar problem given in PISA study (see OECD, 2003). In PISA study, the problem was about the **minimal** unit cubes that are needed to make a blocks like figure B (*note*: the answer is 26 (27-1)). Nonetheless, there were still many students who have not been able to answer the easier problem.

In relation to mathematics curriculum in Indonesia, the topic about the given problem has been studied by the students in elementary and junior high school. Therefore, it should not be difficult for the students to determine the volume of a cube (using the formula). However, research findings indicated that the students have not been able to use the formula. It is evidence here that the students already know the formula, but they are not able to use it when necessary.

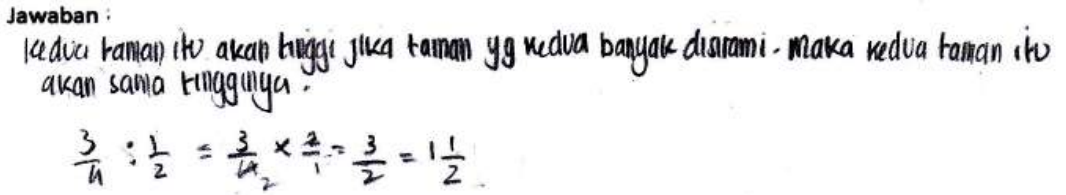
Based on this finding, it is argued that the students have learned about the formula of cube volume in a mechanistic way (see Fauzan, 2009), so that they only able to memorize the

formula but do not know when and how to use it. Students need to be involved in finding the formula through *hands-on- activity* (the volume of a cube is found through the use of unit cubes). However, it is rarely found that mathematics teachers who provide this kind of learning experience to their students.

Mathematical literacy of students of junior high school in West Sumatra for connection cluster was not as good as for reproduction cluster. This finding revealed that the students lacked of capability in understanding the relations among mathematics topics, of mathematics topic to other subjects, and to the problems of everyday life. These findings can be seen from the following examples.

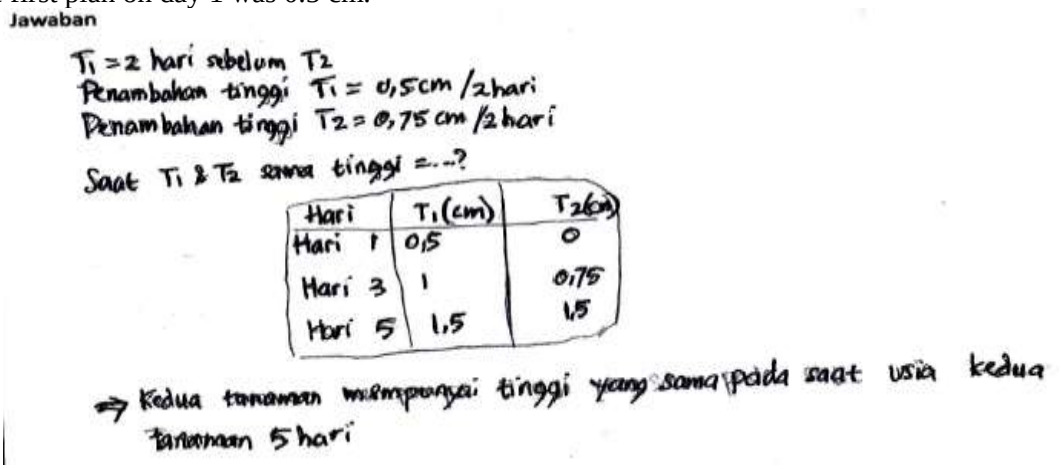
> *There are two plants; the first plant grew two days earlier than the second one. Every two days the first plant grows ½ cm in height and the second plant grows ¾ cm. When will the two plants have the same height? Explain your answer!*

One of the students' answers is:



The answer showed that the student did not understand the problem so that he only used *common sense* to solve it. He has just tried to operate the numbers found in the problem, although it was not relevant to the question. These finding is relevant to what is mentioned by Figueirerdo (1999) that the student who have been taught by using conventional word problems are likely only going to use all available numbers in question, without understanding.

The next student's answer shows that she understands the given problem. However, the student did not look carefully at the important information that the first plant grows 1/2 cm in height for every two days. As a result, she got a wrong analysis by mentioning that the height of the first plan on day 1 was 0.5 cm.



For reflection cluster, the majority of the students (nearly 80%) in West Sumatra have only reached only low or moderate scores. Meanwhile, nearly 53% of students achieving only a low score. These results are also similar to the results of previous PISA studies which showed that the percentage of Indonesian students who are able to solve the problems that require a high degree of ability to think very little (OECD, 2010b; Stacey, 2011).

When the findings that have been described previously linked with data from the questionnaires filled out by the teacher, it was found some factors that could explained the results. In general, mathematics teachers at junior high schools who have been involved in this research, did not have a good knowledge about PISA, mathematical literacy, and mathematical ability. Although the goals of the mathematics curriculum for junior high schools in Indonesian is in line with the content of PISA studies, but most mathematics teachers have not paid sufficient attention to the objectives to be achieved through the learning of mathematics in schools.

It is argued in this study that the lack of knowledge of mathematics teachers on mathematical literacy and mathematical ability directly impact their ability to design questions to assess students' mathematical literacy and mathematical ability. Although the ability of some mathematics teacher from the high level schools was quite good, but they acknowledge that the questions to assess students' mathematical literacy and mathematical abilities rarely given to students.

It is believe that one of the external factors that influence the findings of this research is the system of National Examination (UN) in Indonesia. The role of the UN, which is much bigger than it supposed to be, is causing all the schools put "successful in UN" as a priority in education. In mathematics learning, teachers are more focused on the demands of Competency Standards (SK) and the Basic Competency (KD). Because of these situations, mathematics teachers have no room and intention to develop mathematical literacy and mathematical ability of the students. As the problems presented in UN tend to measure low cognitive levels, consequently mathematical literacy and mathematical ability of students in Indonesia are not well developed (see Stacey 2011).

This condition needs serious attention from the government, particularly the Ministry of National Education. The function of mathematics in the curriculum is to equip students with the knowledge, values, and skills (especially thinking skills) that can help and enable them to face future challenges. If mathematical literacy and mathematical ability are ignored in the curriculum, then the function could not be realized.

CONCLUSION

Based on the results of research and discussion, it can be concluded that:

1. Mathematical literacy of the students of junior high schools in West Sumatra, for reproduction cluster, connection, and reflection, has not been satisfactory.
2. Mathematical ability of students of junior high schools in West Sumatra, which includes representations, connections, problem solving, reasoning, and communication, tends to be low.
3. The factors that lead to low levels of mathematical literacy and mathematical ability of students are:
    - mathematics teachers are not familiar with PISA studies and mathematical literacy;
    - knowledge and skills of mathematics teachers in designing questions to assess students' mathematical ability is not sufficient;
    - mathematics teachers rarely give problems which aims to develop students' mathematical literacy and mathematical ability.

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