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Eighth Grade Students Mathematical Problem Solving Ability: Public School Case

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***Abstract*— Mathematical problem solving ability (MPSA) plays an important role both in studying mathematics and in human daily life. It, therefore, makes sense if MPS becomes central and important to be grasped by the students from elementary to senior high school. Researchers had paid much attention on cultivating and fostering the students' competency albeit the fact revealed that it remains belonged to a low category. This article reports the first stage of a research aimed at developing instructional materials based on discovery learning in order to improve students' MPSA. The research takes place at four public junior high schools (PJHS) selected from Medan and District of Deli Serdang, Indonesia. The findings of the research are: (1) the students' MPSA is low; (2) the students experience difficult at almost every aspect of MPSA; and (3) neither exists variation in using strategy nor does any aid to attain the solution, (4) The solution of the problem lacks of explanation.**

Keywords*— *eight grade, Mathematical problem solving, ability, Public school

I. INTRODUCTION

Mathematical problem solving is viewed as a process of applying knowledge to solve mathematical problem, especially non-routine problems; a product of doing mathematics, that is, any problem solving yields a solution (outcome); a skill or ability to solve a mathematical problem. To solve a mathematical problem, one needs to understand, to reason, to represent, to connect and to communicate. All of these competencies are used when solving problems. Vice versa, the uses of these five capabilities strengthen problem solving abilities.

Recent research in public upper secondary schools in Bandung revealed that Indonesian students' MPSA is under performed [1]. Overall, they only scored 9.95 in the experiment and 8.09 in the control group of ideal score 28. One of the aspects of MPSA experienced difficult by the students is at the aspect of representation (visual and mathematical equation) as a component of mathematical understanding [2] and the strategy used to solve the problem [3]. Low of mathematical problem solving ability is also reported in [4] and [5]. It is alleged that low of students' MPSA is due to learning factors, i.e. teacher-centered learning. Therefore, many researchers tried to apply student-centered learning that allegedly can improve students' MPSA, for example [6], [7], and [8].

Actually, low MPSA of the students is not only a problem in Indonesia but also in some other countries like Malaysia, Filipina, Thailand and some other countries. To overcome the problem, for example, Singapore has developed a curriculum based on the Mathematics Framework since 1990 and continues to develop it for a curriculum that fits in with the development of students' mathematical problem solving abilities [9]. Likewise, Indonesia revised curriculum periodically in order to fit in the need to improve students' problem solving ability. Current used is 2013-Curriculum, which is a revision of 2006-Curriculum. As well as the prior curriculum, this one also emphasizes on problem solving skills but with a strong emphasis on soft skills. Another effort to overcome the problem is that the ministry of education gives the opportunity to educators to do research in order to improve the problem solving ability of the students, to reduce the discrepancy between facts and expectations regarding students' MPSA. The literature study shows that to overcome the discrepancy is through developmental research [10].

By considering these reports, we are trying to investigate how are the MPSA of the students at public junior high school (PJHS) A Medan, PJHS B Tembung, PJHS C Lubuk Pakam, and PJHS D Binjai. These schools are all located in North Sumatra Province, Indonesia. The finding described in this paper is the result of first year of three years proposed. Therefore, this stage carried out observation, interview, and essays test.

1.1 Mathematical Problem solving

Already stated in the formerly Indonesian curriculum (K-13), that mathematics is a universal knowledge useful in human life, underpin modern technology development and has an important role in every area of science. In addition, Singapore's director general of education [9] stated that mathematics plays an important role in the development of a nation and its people. At the individual level, mathematics underpins many aspects of our everyday activities, from making sense of information in the newspaper to making decisions about personal finances. It supports learning in many fields of study, whether it is the science or humanities. A good understanding of basic mathematics is essential wherever calculations, measurements, graphical interpretation and

statistical analyses are necessary. At a national level, a strong grounding in mathematics is essential to support an innovation and technology-driven economy.

K-13 put the focus on teaching learning mathematics as an effort to enable students mastering in problem solving so the students will never be left behind in the era of innovation and technology. The problem itself is not only something that has failed or is not working well but also finding a better or new way, analysing why something happened, creating a plan, making artefact or work of art, anything that prevents someone from readily accomplishing an objective [11]. They also said that when there are several possibilities to be considered or ways to do something, there is a problem. The characteristic of a problem is something that never sufficient information to fully analyse or solve it, seems messy or fuzzy. A problem needs more than one step to solve it, there are various ways to solve and maybe more than just one solution [12], it is new and unfamiliar but it emerges to be solved [13].

We confronted problems almost in every area of life. Problem is not only experienced by students but also by the common citizen. Students may face mathematical problem related to algebraic manipulation while common citizen experiences the financial freedom problem. Problem solving is the action to solve these problems, to attain the solution. National Council of Supervisors of Mathematics (NCSM) explains that solving a problem is the process of applying knowledge to an unknown and unfamiliar situation [14]; problem solving is a component of decision-making [15]; problem solving is a vehicle for learning new concepts and skills [16]. In addition, problem solving is not merely seeking for a right answer, but more as a way to develop logical and creative thinking because one does not directly have a certain way to solve the problem [17].

Especially in school mathematics, [16] stated that problem solving could be considered as a process, ability, or skill; the role of problem solving is as context, skills, art. According to [9], mathematical problem solving involves the acquisition of mathematics concepts, and skills in a wide range of situations, including non-routine, open-ended and real-world problems. The development of mathematical problem solving ability depends on five inter-related components, namely, concepts, skills, processes, attitudes, and metacognition. Mathematical concepts cover numerical, algebraic, geometrical, analytical concepts. Mathematical skills include procedural skills for numerical calculation, algebraic manipulation, spatial visualization, data analysis, measurement, use of mathematical tools, and estimation. Mathematical processes refer to the knowledge skills or process skills involved in the process of acquiring and applying mathematical knowledge, including reasoning, communication and connection, thinking skills, heuristic, application, and modelling. Attitudes refer to affective aspects of mathematics learning, such as beliefs about mathematics and its usefulness, interest and enjoy in learning mathematics, appreciate the beauty and power of mathematics, confidence in using mathematics, and perseverance in solving a problem.

Thus, mathematical problem solving should be grasped by the students because through problem solving students are trained to be a decision maker, thinking constantly to apply their knowledge, learning to use tools to master mathematical concepts and problem solving strategies, cultivate logical and creative thinking, build metacognition and positive attitude towards mathematics.

RESEARCH QUESTION

The questions of the research are:

1. How is mathematical problem solving ability of PJHS students grade eighth?
2. In what aspects of MPSA do students face difficulties?
3. How is the variation of the strategy the students use to solve the problems?
4. What type of visualization the students used to represent the problem?

II. RESEARCH METHOD

The subject of the research is public junior high school (PJHS) students grade VIII, they are class A from PJHS 17 Medan City; class B from PJHS 2 Binjai, class C from PJHS 1 Lubuk Pakam and class D from PJHS 4 Tembung District of Deli Serdang. The research result is problem identification related to students' mathematical problem solving ability (MPSA). To collect data about students' MPSA, as many as 10 students from each class followed the test. Totally, there 40 students included in MPSA test. The test consists of five items that designed based on standard process of problem solving aspects proposed by [3], that is (a) Understand the problem; (b) Propose strategy; (c) Execute the strategy; and (d) Explain and interpret solution in accordance to initial problem. Indicators of each aspect of MPSA are presented in Table 1.

TABLE 1 Indicator of MPSA

No	Aspect	Indicator	Score
1	Understanding the problem	Represent the problem in picture (sketch), graph, chart, diagram, mathematical equation, or symbols	1
2	Propose strategy	Propose appropriate technique or method to solve the problem	1
3	Execute the strategy	Show true calculation or algebraic manipulation	1
4	Interpret the solution	Explain the solution in accordance to initial problem	1
	Total		4

Problem 1 is an example of problem that required the students to (a) sketch a beam ABCD.EFGH as the first indicator; (b) propose Pythagorean rule to determine two diagonals which form the area BDF as the second indicator; (c) calculate the area of triangle, as the third indicator, (d) and Explain the solution as the fourth indicator.

Problem 1
A beam ABCD.EFGH has width of 5 cm, length 12 cm, and height 20 cm. Determine the area of the BDF triangle. Explain your answer.

Each test item measures these four indicator, so score for each item test is four. The total score of five items is 20. We transform total score of the test into scale 100. Classification of MPSA follows the criteria in K-13 [18] with slight modification in order to fit with the data. The classification is presented in Table 2.

TABLE 2 Classification of students' MPSA

Category	Score (X)
Excellent	$80 \leq X \leq 100$
High	$70 \leq X \leq 79$
Medium	$60 \leq X \leq 69$
Low	$X < 60$

III. RESULT AND DISCUSSION

The result of the research is the answer for the research questions, thus it will be describes about mathematical problem solving ability of PJHS students grade eighth, the aspects of MPSA do students face difficulties, the variation of the strategy the students use to solve the problems, and the type of visualization the students used to represent the problem.

A. Students mathematical problem solving ability

The description of mathematical problem solving ability (MPSA) of the students is presented in Table 3. Total score for five items MPSA test is 20. Data in the table describe the students' MPSA average at each school. There are 10 students at each PJHS administered the test. The highest average achieved by the students from PJHS A Medan, which is 49.1 %. Overall, the average achievement of MPSA is 47.5%. Based on Table 2, this achievement is still low. Overall, the average achievement of MPSA is 47.5%. Based on Table 2, this achievement is still low.

TABLE 3 Statistic of students MPSA

School	Average	%Average	SD
PJHS A	9.82	49.1	1.414
PJHS B	9.64	48.2	1.414
PJHS C	9.46	47.3	1.414
PJHS D	9.09	45.5	0.707

The result of observation revealed that teaching and learning in the classroom still dominated by direct instruction with the expository approach. The students tend to keep silent listening to their teacher explain each topic of mathematics. The students rarely ask the teacher to repeat the explanation if they have not understood part of the topic yet. The result of interview shows that it is difficult for teachers to replace conventional learning models with constructivism-based learning that promote students' engagement in a learning process. They argue it is because of time limitation. The results of observation and interviews are in line with the theory that conventional learning could not be relied upon to improve mathematical problem solving ability because this learning does not carry the principle of students to be active in learning and construct their own mathematical knowledge or concept. The principle is the underlying principle of student-centred learning [19].

Figure 1 is an example of the solution given by Student X and Figure 2 is an example of the solution given by Student Y for Problem 1.

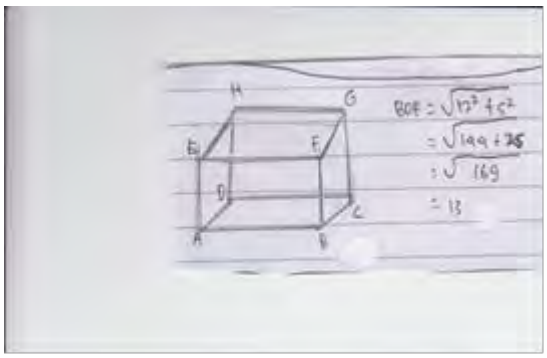


Fig. 1. Student's work in problem 1: Student P

The solution given by student P showed that he tried to draw a beam but still made mistake in creating edge BC; actually, BC should be parallel to FG. The second mistake is that he determined BD as BDF, it shows that he did not understand the difference between BD and BDF, so he stuck, could not continue the process of solving the problem. Moreover, this student has not fully understood the problem yet; he creates a picture of a beam but does not write (represent) suited information from the problem in that picture.

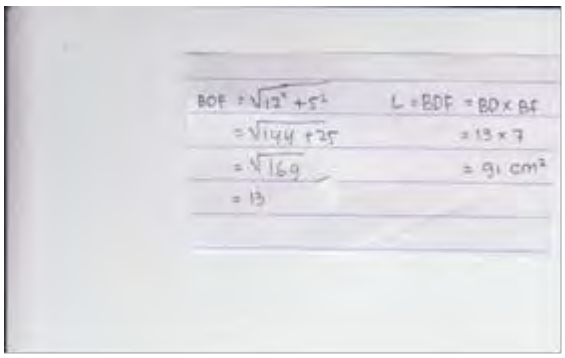


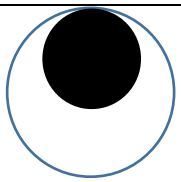
Fig. 2. Student's work in problem 1: Student Q

Student Q could not draw the picture of a beam that probably will aid him to determine the length of BF. Furthermore, instead of specifying the area of BDF as half of BD times BF, he simply multiplies BD and BF. Even he did not explain and interpret solution in accordance to initial problem. On the other hand, he does not know how to determine the area of

triangle BDF, and it is because he could not see the position of BDF embedded in a beam. Therefore, he did not attain the correct solution for this problem. Many students who followed the test gives this kind of solution; they could not represent the problem in a picture or other visual representation. They lack visual representation (create picture, graph, chart, diagram, symbol) as part of first indicator of MPSA.

Problem 2

Look at the figure.
The area of the small circle (Black-Colored) in the figure is 200 cm^2.
Determine the area of the large circle area that is no color if the diameter of the large circle is twice the diameter of the small circle.



The purpose of Problem 2 is to elicit students' ability in converting information into picture or figure. Then, they should interpret every key concept presented in the picture of circle into mathematical symbol, then state mathematical equation or formula to find the area of a circle, determine area of a small circle and area of a large circle that uncovered by a small circle, and finally conclude the solution in line with the initial problem.

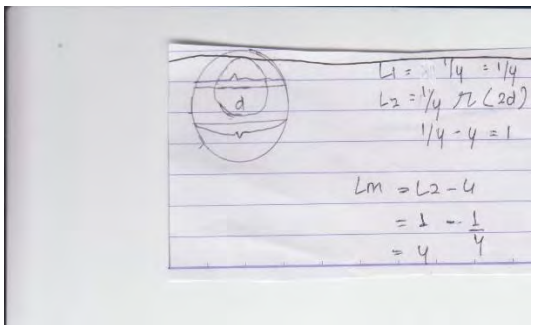


Fig. 3 Student' work for Problem 2: Student R

Based on the work in Figure 3: Student R shows his knowledge about the diameter of both circle, know how to determine the radius of a circle. Unfortunately, the formula for counting area of a circle he proposed is wrong. The type of this solution is prevalent among students. This type of solution gives a significant contribution to the overall score of MPSA.

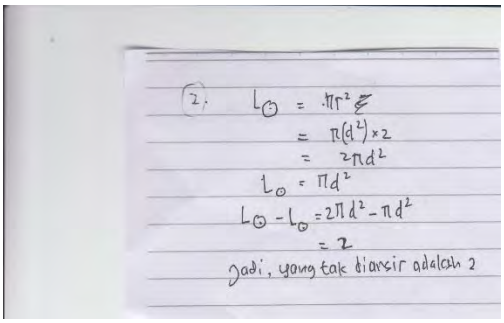


Fig. 4 Student work for Problem 2: Student S

The next one, student S could not draw the picture of a circle to represent this words problem. In this case, he did not remember the right formula to find an area of a circle. As many other students, he only knows that area of the circle is πd^2, instead of πr^2.

Overall, the students' mathematical problem solving ability in this prior research belongs to the low category; the average score is 47.5 with ideal score 100.

B. Aspects of students' mathematical problem solving

Data of overall students' MPSA score shows that more than half of the students solve the problem as in Figure 2 where there is no mathematics equation used to compute the area of a circle, even, no mathematical symbol to represent the radius of the circle. As known, representation is an important part in the process of mathematical problem solving [2], because the role of mathematical representation in the process of problem solving is to make the problem easier to understand and probably enable the student to consider the strategy used in the rest of problem solving.
Most of the students faced the most difficulty in representing a problem in visual representation as an aid to help them attain the solution. Representation along with connection is component of understanding [20]. Some researcher conjectured that the students' low capability in understanding is because of teaching and learning in the classroom is dominated by the teacher-centered approach that did not plot the time for students to engage in a problem solving activity ([2], [11], and [19]). We need student-centered teaching learning to improve students' achievement in mathematics [21].

C. The strategy used to solve problem

Overall, the performance of the students in solving mathematical problems is lack of visualization. For example, problem 1 required the students to visualize a beam so they can see the position of BDE plane. Even though there are few students draw the figure of a beam, it is not precise. There are some students draw a picture of a beam perfectly, but mistakenly sets the length of the diagonal field such that they did not attain a right solution.

D. Type of visualization the students used to represent the problem

By examining the entire students answer sheet, the researchers arrive at the conclusion that problem- solving strategy the students used is not varies. As an example, to solve problem 2, the student does not use a strategy at all. He calculates the area of a circle directly without using formulas or logic, so the result is wrong. For this problem, at least there are two strategies can be used. First, calculate the area of each circle; the second one is to use the comparison of each area of the circle without using the length of their diameter.

IV. CONCLUSION

Based on analysis of the data, the researchers conclude that:

a. The students' mathematical problem solving ability (MPSA) belongs to low category. The students MPSA achievement is only 47.5% (see Table 2).
b. The students faced difficulty at almost every aspect of MPSA, especially at the aspect of representation.
c. There is no variation in using strategy as an aid to attain the solution.
d. The solution of the problem is poor visualization

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