Secondary students' higher-order thinking skills in solving PISA- like mathematical tasks

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Abstract. Higher order thinking skills have become one of the main focuses in learning mathematics based on Indonesia curriculum currently. One of the teacher's efforts to help students to develop higher order thinking skills is to provide questions like PISA questions. This is because PISA is a test of students' abilities on an international scale, which also serves as a benchmark for the mathematical abilities of Indonesian students. This study is a descriptive type qualitative study. It purposed to describe students' mathematical ability especially related to their higher order thinking skills in solving tasks like PISA tasks. Six secondary students consisting of 3 boys and 3 girls with different type of mathematical abilities were involved as research subject. Data were gathered through observation, interview, and documents such as students' worksheets and they were analyzed qualitatively. The result showed that the most dominant skill appeared among analyzing, evaluating, and creating skills is analyzing skill. Although students sometimes made mistakes in determining final answers, they indicated trying to develop their skills by solving problem categorized as analyzing, evaluating or creating problem.

1. Introduction

The 21st-century learning demands have influenced the recent curriculum orientation in Indonesia [1-2]. The curriculum emphasizes Higher Order Thinking Skills (HOTS) in the teaching and learning process including in mathematics learning [2]. These skills require students to be able to analyze, evaluate, and be creative in solving problems that they face [3-4]. It also has a role in supporting 21st-century skills which include collaboration skills, communication, critical thinking, and creativity [5-6]. However, based on the results of PISA, Indonesian students are seen to be still dominant in Lower Order Thinking Skills (LOTS) in which Indonesian students are only able to solve problems related to knowledge, understanding, and application that are categorized as LOTS level questions [7-9].

Various attempts were made to help students to develop their higher-order thinking skills in the learning process. Several previous studies have been carried out including the development of PISA type math problems using various contexts in Indonesia [10-16] and also the use of technology in developing this kind of problem [2]. However, these efforts will not be optimal if it is not balanced with an analysis of how students' abilities when they work on HOTS type PISA questions. The analysis results of student abilities can be used as a reference to provide other supports needed by students. Thus, this study aims to provide a description of students' higher order thinking skills when they solve PISA like mathematical problems that are categorized as HOTS problems.

2. Method

This study uses qualitative study as a research methodology. The type is descriptive study which consist of 3 main stages namely preparation stage, implementation stage, and analysis stage. At preparation stage, research instruments like observation and interview questions are developed based on HOTS indicators. According to Krathwohl [17-18], higher order thinking skills are categorized into skills to analyze, to evaluate, and to create. Their indicators are described as follow:

Table 1. Indicators of Higher Order Thinking Skills

Higher Order Thinking Skills Indicators		
Analyzing Skill	Evaluating Skill	Creating Skill
• Differentiating Distinguishing part of materials according to its relevant or its important • Organizing Identifying elements and finding their fit or function in forming a structure • Attributing Determining a point of view, values, bias related to presented materials	• Checking Detecting a process or product according to its internal consistency, its fallacy or its effectiveness • Critiquing Detecting whether a product has external consistency and detecting the appropriate procedures for a given problem.	• Generating Generating hypotheses based on criteria • Planning Designing a procedure to solve problem • Producing Creating a product or

At implementation stage, observation and interview to research subjects are conducted and the data collected is analyzed at the next stage. The research subjects were selected by purposive sampling so that 6 students aged 12 years were selected consisting of 3 boys and 3 girls in junior high schools in Palembang. Data was collected through observation, interviews, and student worksheets and they were analyzed qualitatively. There are 3 stages carried out in analyzing students' high-level thinking skills, namely the data reduction stage, the data presentation stage, and the conclusion stage

3. Result and Discussion

PISA like mathematical tasks and research instruments were prepared. There were six PISA like mathematical problems provided. Observation and interview sheet were developed considering to the indicators of higher order thinking skills.

At implementation stage, students were asked to solve mathematical problems given. During they solve the problems, researcher observed their performance and made some notes. At the end of session, students were interviewed related to what their opinion and their understanding about the tasks, how they solve the tasks, and what the reason behind their strategy. The interview session were also done to clarify some notes made when they were observed.

The data collected through observations, interviews, and students' worksheet were analyzed qualitatively. The following are some examples of students' works and their analysis related to their higher order thinking skills.

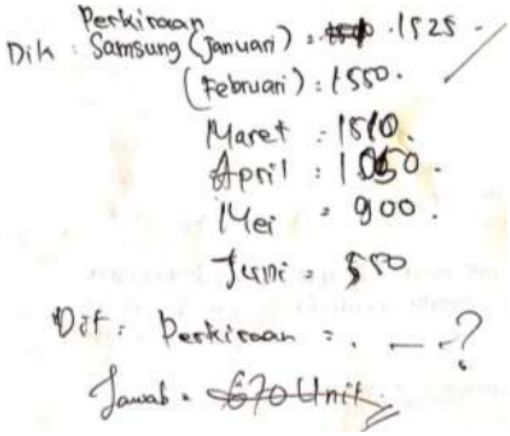

Figure 1. Students' work on problem categorized an analyzing type.

Figure 1 shows that the student was able to identify information on the problem. She could write down information related to the problem and what the question about. The question is about estimation of smartphone number in the next month if trend is continued. She tried to estimate appropriate number based on the graph given. The way she determine the number of smartphone is indicated into analysis skill since she could identify information from graph given and connected relation between information to find out the number of smartphone. However, she made mistake in assuming, she thought that number must be more than 550, then she decided the number of smartphone in the next month is 670 unit. Students' ability in solving this problem is categorized into analyzing skill. What the student did in figure 1 directed to indicators of the analyzing skill however teacher need to support the student to develop her skill by posing clues or questions to convince whether she made right answer or not.

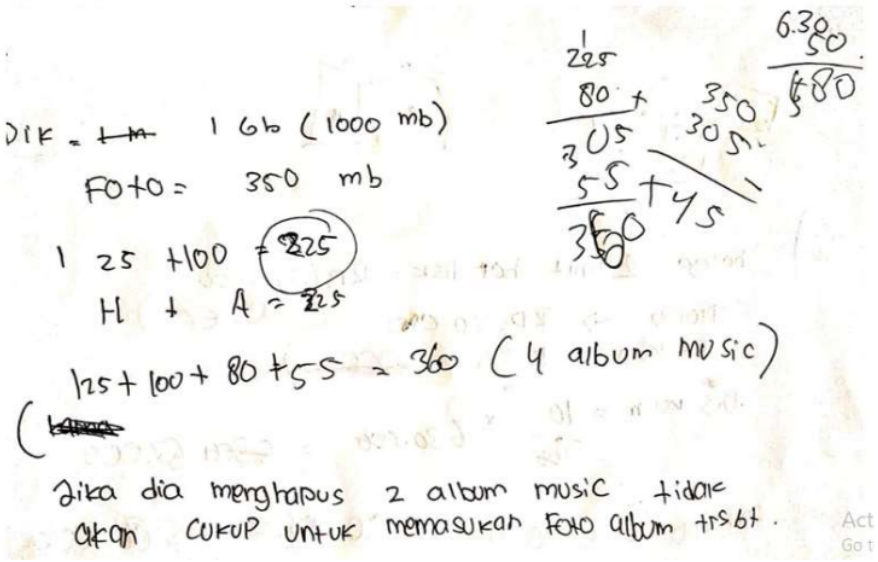

Figure 2. Students' work on problem categorized an evaluating type.

Figure 2 shows that the student know what the problem about. It looks from the way she wrote down some information and the question related to the problem. The question asks students to check whether she could delete two music albums, therefore, there is more space in flash disk to be replaced with a new photo album. The students tried to add up 4 album capacities approaching to the photo album capacity. However, she forgot that there was still some space in flash disk so that she thought that she could not delete just two albums since the sum of 4 albums were also not enough. The student tried to evaluate the statement given through doing some calculations to check whether it true or false. However, she did not recognize other possibilities since she believed that the sum of 4 album capacities was not enough to give more space for new photo album. The way she did shows that she still needs to develop her evaluating skill because she made a mistake in checking the truth. However, not all evaluating problems could not be solved by students. The following is an example of students' work in evaluating in right manner.

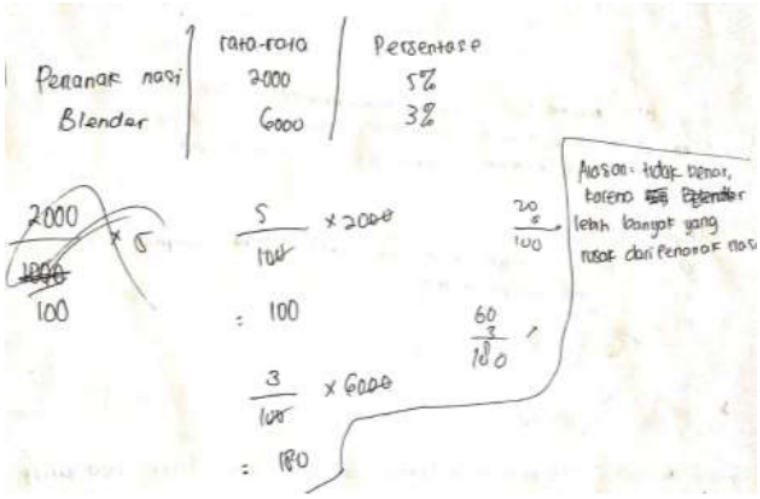

Figure 3. Students' work on problem categorized an evaluating type

Figure 3 shows that the student calculated the number of each item according to its percentage and compared the numbers to check the truth of statement given. She could identify information given in problem and made connection between them. She made some calculations in right way and use them in evaluating the statement. What she did actually fulfills the indicators of evaluating skill since she can detect the fallacies in the problem.

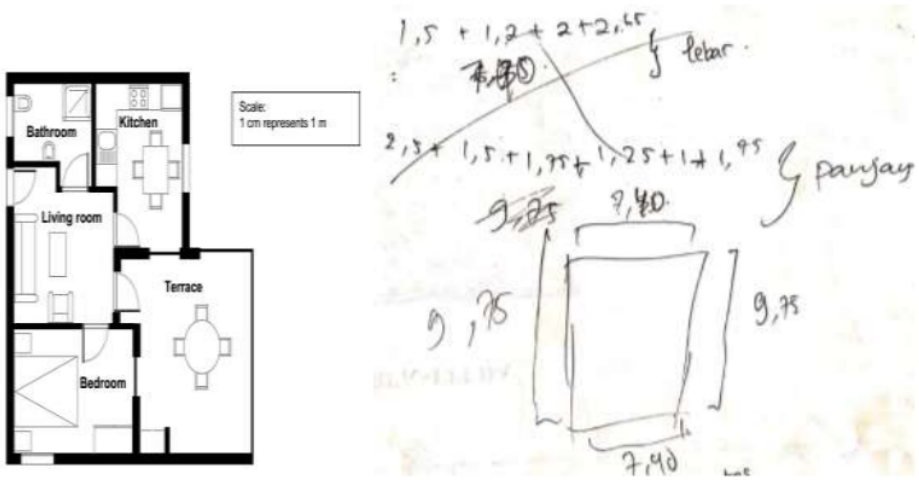

Figure 4. Students' work on problem categorized a creating type

Different from other problems solved by students, figure 4 shows that the student seems difficult to sketch solutions matching to the problem. The problem is about marking 4 sides on the floor plan needed to determine the overall floor area. To solve the problem, the student calculated the length and width of the floor plan. She used their sizes in determining the floor area. However, the solution does not fit the problem given. The sketch made does not represent the floor area. This shows that the student was not able to create a solution that solves the problem.

The analysis results of this study are similar with the PISA result of Indonesia students indicating that Indonesia students are still week in analyzing skill, evaluating skill, and creating skill [7-9]. However, teachers can help students to develop their mathematical skill though mathematical tasks that can stimulate student to think [19-21]. Therefore, giving mathematical tasks categorized as HOTS tasks is also good way in supporting student to develop their higher order thinking skills [22-23].

4. Conclusion

Students' higher order thinking skills in solving PISA like mathematical tasks include analyzing skill, evaluating skill, and creating skill. Among those skills, the most dominant skill is analyzing skill. Students' evaluating and creating skills are good enough although they sometimes make mistake in determining final results. Therefore, students should be helped by posing clues, questions, and more HOTS tasks.

5. Acknowledgments

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