Pre-service mathematics teachers’ ability in solving well-structured problem

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Abstract. This study aimed to describe the mathematical problem-solving ability of undergraduate students of mathematics education in solving the well-structured problem. The type of this study was qualitative descriptive. The subjects in this study were 100 undergraduate students of Mathematics Education at one of the private universities in Palembang city. The data in this study was collected through two test items with essay form. The results of this study showed that, from the first problem, only 8% students can solve it, but do not check back again to validate the process. Based on a scoring rubric that follows Polya strategy, their answer satisfied 2 4 2 0 patterns. But, from the second problem, 45% students satisfied it. This is because the second problem imitated from the example that was given in learning process. The average score of undergraduate students mathematical problem-solving ability in solving well-structured problems showed 56.00 with standard deviation was 13.22. It means that, from 0 – 100 scale, undergraduate students mathematical problem-solving ability can be categorized low. From this result, the conclusion was undergraduate students of mathematics education in Palembang still have a problem in solving mathematics well-structured problem.

1. Introduction

On mathematics curriculum, the problem-solving ability is a very important. In the learning process, Students gain an experience by using their previous mathematics knowledge to solve the routine or non-routine problem. Mathematics problem solving is a process that uses the concepts of mathematics in solves a mathematics problem. In mathematics education, problem-solving is one of important ability to develop students’ mathematics thinking. With mathematical problem solving, students will understand mathematics meaningful because the concepts or principles can be applied to solving a problem. The importance of mathematical problems solving ability, according to Wilson [1], is the main goal of mathematics teaching and learning.

Based on the author experience, most students had difficulty when solving a mathematics problem. This was indicated by the results of a test that the author gives the lecture, while the problem is basic. This was a reason that encourages the authors to conduct this study. Preliminary observation to undergraduate students of mathematics education at one University in Palembang who take applied mathematics class showed that they are not able enough to solve mathematical problems relate to the real world and do not get used to delivering a mathematics idea in oral and written form. They difficult determined the exact problem, found a strategy, and determined a usable pattern. The students could solve mathematics problem if they were given mathematics symbols and figures directly so that they knew what to solve immediately without interpreting the problem first. A question of "why" is hardest to answer them.
NCTM [2] stated that mathematics problem solving is a tool and an objective in learning mathematics. It is very recommended to be given from elementary school until university. Through problem-solving, the way of student’s thinking will be used to face nonprocedural problems. According to Kirkley [3], there are three types of problem, which is well-structured problems, moderately-structured problems, and ill-structured problems. Well-structured problems have characteristic, that is the strategy of problem-solving is usually more than one, and all information available in order to solve the problem directly. The characteristic of moderately-structured problems, that is the strategy of problem-solving is usually more than one, has one solution, and needs additional information in order to solve the problem. The last, ill-structured problems have characteristic, that is difficult to allegedly, the strategy of problem-solving has many perspectives, any solutions, and needs additional information in order to solve the problem.

Mathematics problem solving has two significances in learning. As a learning approach, mathematics problem solving is an approach that provides a contextual problem as starting point and then reinvention gradually and understands mathematics concept or principal. As an ability, It must be reached after learning process, problem-solving is an activity which the solution to a problem doesn’t know yet or no immediately found. In solving a problem, the student must integrate his/her knowledge by developing his/her new understanding. Generally, problem-solving is nonroutine. Hence, this ability is classified as high order mathematics thinking ability [4]. Nonroutine problem is interpreted by Arslan and Altun [5] as a problem that different from usual and cannot be solved with general strategy. This problem can relate to the real-life situation or not, but it’s always be conceived in real life model situation.

The mathematical problem solving that was used in this study refers to Polya [6]. The four steps to solve the mathematics problem are (1) understanding the problem, (2) making a plan, (3) executing the plan, and (4) re-examining the answer. At the stage of understanding the problem, the student must be convinced that a problem can be solved in several ways, read repeatedly, determine what is known, what is unknown, and seek the purpose of the mathematical problem. At the stage of creating a plan, students can observe the relationship between known and unknown information. At this stage, the calculation is performed to an unknown variable. It will obtain the answer to the question about how the known information interconnects to unknown. At the stage of executing the plan, the students check each step that outlines in the plan and writes it in detail to ensure that each step is correct. At the re-examining stage, students look back at the answer to make sure that the answer to the problem is correct. Based on that background, the purpose of this study was to describe mathematical problem-solving ability of undergraduate students of mathematics education in solving well-structured problem.

2. Methods
The method of this study was descriptive qualitative. The instrument in this study tested. The subject of this study was 100 students of Mathematics Education in one of the private Universities at Palembang who take Applied Mathematics class of academic year 2016/2017. Mathematical problem-solving ability was measured using an essay test. The indicators of mathematical problem-solving ability in this study were: (1) understanding the problem; (2) plan for problem solving; (3) implementing a problem-solving plan; (4) re-examination. The following is a scoring rubric of mathematics problem-solving ability that pursues Polya strategy:
3. Results and Discussion

The general description of this study was mathematical problem-solving ability of undergraduate students of mathematics education in solving well-structured problem. The test was conducted after the lecture about applied mathematics is finish. Learning method that is applied in learning process was expository. The first test item is “a cup of milk with a temperature of 60° C is placed indoors with a temperature of 10 C, in 30 minutes the temperature of milk decreases to 40° C. How long does it take for the temperature to cool from 60° C to 30° C, then how long does it take to cool from 50° C to 30° C”.

The second test item is “a bacterial colony increases at a rate proportional to the amount of material present. If the number of bacteria tripled within 5 hours, how long will it take for the number of bacteria to multiply 5”. Students’ answer analysis on both problems used the rubric of Sumarmo [4].

Table 1. The Scoring Rubric of Mathematics Problem Solving Ability Following to Polya Strategy

| Score | Understanding problem | Constructing plan | Performing calculation | Checking back the result |
|-------|-----------------------|-------------------|------------------------|--------------------------|
| 0     | Misinterpretation or incorrect at all | No plan, irrelevance of constructing plan | Not performing calculation | Not checking back |
| 1     | Misinterpretation partially, disregard of problem condition | Constructing a plan, but it cannot workable | Performing the right procedure and probably produce a correct answer but miscalculate | Checking back but incomplete |
| 2     | Understanding problem clearly | Constructing the right plan but incorrect in the result or no result | Performing the right procedure and getting a correct answer | Checking back to see the validity of process |
| 3     | Constructing the right plan but incomplete |
| 4     | Constructing a plan that appropriates with procedure and set in a correct answer |

Max score is 2  Max score is 4  Max score is 2  Max score is 2

Source: Sumarmo [4]

Table 2. The percentage of the pattern of students’ answer based on the first problem

| Score of students answer analysis | Number of Students Percentage |
|----------------------------------|------------------------------|
| Understanding Problem            |                             |
| Constructing Plan                |                             |
| Performing Calculation           |                             |
| Checking Back                    |                             |
| 2                                |                             |
| 2                                |                             |
| 2                                |                             |
| 2                                |                             |
| 2                                |                             |
| 2                                |                             |
| 2                                |                             |
| 2                                |                             |
| 2                                |                             |
| 2                                |                             |
| 1                                |                             |
| 1                                |                             |
| 1                                |                             |
| 1                                |                             |
| 1                                |                             |
| 0                                |                             |
| 0                                |                             |

8%  4%  22%  15%  10%  5%  27%  2%  1%  6%
Table 2 shows that 8 of 100 students can understand the problem clearly, can construct the plan correctly and completely, can perform the procedure correctly so that produce the correct answer, but do not check back again to validate the process. 4 of 100 students can understand the problem clearly, can construct the plan correctly and completely, can perform the procedure correctly but the final answer is not correct, and they do not check back. 22 of 100 students can understand the problem clearly, can construct the plan correctly but incomplete, can perform the procedure correctly but the answer is not correct, and do not check back. 15 of 100 students can understand the problem clearly, construct the plan inappropriately and incompletely, can perform the procedure correctly but the answer is wrong, and they do not check back. 10 of 100 students do some errors. One of the errors is to ignore the conditions in determining the temperature decrease from 50 to 30. This can be seen from incomplete plan, but the process for the initial conditions is correct. 5 of 100 students make mistakes in understanding the problem, can construct the plan correctly and incomplete, can perform the procedure but produce the wrong answer, and do not check back. 27 of 100 students make mistakes in understanding the problem, construct the plan inappropriately and incompletely, can perform the procedure correctly but the answer is wrong, and they do not check back. Errors that occur are the students ignore the conditions in determining the temperature dropped from 50 to 30, make the right plan but wrong in the result because they implement procedures that probably far from correct answer. 2 of 100 students make mistakes in understanding the problem, not constructing the plan, can perform the procedure with the answer is not correct, and do not check back. One of them wrote, $s(0) e^{at} = 3 s(0)$. It should be written $s(0) e^{at} = 5 s(0)$. It seems the plan that he/she makes indicate the calculation will correct, but the answer is irrelevant so that it leads to impossibility to produce the correct answer. The rest of them were unable to solve the first problem ranging from not being able to interpret the problem until not checking again.

The pattern of students’ answer based on the first problem forming 10 patterns. It is different with the patterns that occur from students’ answer based on the second problem. 12 patterns were formed by them. The percentage of the pattern is shown detail in table 3.

**Table 3. The percentage of the pattern of students’ answer based on the second problem**

| Score of students answer analysis | Number of Students | Percentage |
|----------------------------------|--------------------|------------|
| Understanding Problem            | Constructing Plan  | Performing Calculation | Checking Back |
| 2                                | 4                  | 2           | 0          | 45%         |
| 2                                | 4                  | 1           | 0          | 1%          |
| 2                                | 3                  | 1           | 0          | 21%         |
| 2                                | 2                  | 1           | 0          | 9%          |
| 2                                | 1                  | 1           | 0          | 1%          |
| 1                                | 3                  | 2           | 0          | 3%          |
| 1                                | 3                  | 1           | 0          | 3%          |
| 1                                | 2                  | 1           | 0          | 5%          |
| 1                                | 2                  | 0           | 0          | 3%          |
| 1                                | 0                  | 1           | 0          | 6%          |
| 1                                | 0                  | 0           | 0          | 1%          |
| 0                                | 0                  | 0           | 0          | 2%          |

Table 3 shows that 45 of 100 students can understand the problem clearly, can construct the plan correctly and completely, can perform the procedure correctly so that produce the correct answer, but
do not check back again to validate the process. It was different with the result from the first problem. This is because the second problem imitated from the example that was given in learning process by lecture. One of 100 students can understand the problem clearly, can construct the plan correctly and completely, can perform the procedure correctly but the final answer is not correct, and do not check back. 21 of 100 students can understand the problem clearly, can construct the plan correctly but incompletely, can perform the procedure correctly but the answer is not correct, and do not check back. 9 of 100 students can understand the problem clearly, construct the plan inappropriately and incompletely, can perform the procedure correctly but the answer is wrong, and they do not check back. One of 100 students can understand the problem clearly, constructing a plan, but it cannot workable, can perform the procedure correctly but the answer is wrong, and they do not check back. 3 of 100 students do some errors. This can be seen from incomplete plan, but the process for the initial conditions is correct. 3 of 100 students make mistakes in understanding the problem, can construct the plan correctly and incompletely, can perform the procedure but produce the wrong answer, and do not check back. 5 of 100 students make mistakes in understanding the problem, construct the plan inappropriately and incompletely, can perform the procedure correctly but the answer is wrong, and they do not check back. 3 of 100 students make mistakes in understanding the problem, do not construct the plan, can perform the procedure with the answer is not correct, and do not check back. 6 of 100 students make mistakes in understanding the problem, do not construct the plan, can perform the procedure with the answer is not correct, and do not check back.

Description from the pattern of students’ answer leads the conclusion that more than 50% undergraduate students of mathematics education still difficult to solve well-structured problem as long as the problem does not imitate the example that is given in learning process. The average score from both problems showed that undergraduate students' mathematical problem-solving ability in solving well-structured problems was 56.00 with standard deviation was 13.22. It means that, from 0 – 100 scale, undergraduate students' mathematical problem-solving ability can be categorized low. The result indicated that they have difficulties in mathematics problem-solving. This result espouses the studies by Tambychik and Meerah [7], Klymchuk and Zverkova [8], Julita [9], and Rusyda, et al. [10]. Student difficulties were revealed through their mistake in answer the problems. Students' mistakes occur because (1) the students are unable to convey what is the question about, (2) students are unable to state what is known and asked, and (3) students have errors in interpreting the language [11, 12]. This is because they make mistakes in understanding the meaning of the problem. It also expressed by Sumargiyani [13] and Widodo [14]. They revealed that there are three types of errors that are often done by students. The three errors are a concept, language interpretation, and computing. Concept errors can be seen to students' misconceptions about what is known and what is asked in the question. The error of language interpretation occurs when the students make mistake in understanding the problem and change mathematics problem in the form of everyday language into the form of a mathematics sentence. Error in computing is the error when students do calculation to find the correct answer. Students who make misconceptions will unable to solve the problem at a later stage. However, students who make misconstruction to both problems will get difficulty to solve a problem at the next stage.

4. Conclusions
In this study, I have succeeded describe mathematical problem-solving ability of undergraduate students of mathematics education in solving well-structured problem at one of private universities in Palembang. The result showed that more than 50% of them still difficult to solve well-structured problem. The average score was 56.00 with standard deviation was 13.22. It means that their ability can be categorized low. From this result, I could conclude that undergraduate students of mathematics education in Palembang still have a problem in solving mathematics well-structured problem.

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