Mathematical problem solving skills analysis about word problems of linear program using IDEAL problem solver

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Abstract. IDEAL problem solver is one of mathematics problem-solving strategies, which function to investigate and describe student’s way of thinking in solving problems process. This research aims to analyze mathematical problem-solving skills using modification IDEAL problem solver. This research aimed to explore, categorize, and analyze student’s problem-solving skills about word problem of the linear program, which can be used as a basis to consider the improvement of learning. This research is a descriptive study including fifteen senior high school students in Grobogan as its subjects. The research variables are indicators of IDEAL problem solver that students performed including identify problems, define the problem, explore solution, act on the strategies, and look back and evaluate. The data were taken in a form of test and interview. The results showed that the indicator identifying the problems are categorized as very poor (8%), indicator defining the problem is categorized as very poor (8%), indicator exploring the solution is categorized as poor (49%), indicator acting on the strategies is categorized as enough (67%) and indicator looking back and learning is categorized as very poor (31%). Most students were not able to identify the problem and define the goal that resulted to lead the interpretation result.

1. Introduction
Mathematics can be used as a tool to make the job easier, more effective, and efficient. This is similar with the statement of [1] which states that mathematics should be taught because (1) it is very essential and useful in various fields, (2) as a powerful, concise, and unambiguous medium of communication, (3) can present the information in multiple ways, and (4) provide satisfaction in solving challenging problems. Mathematics regarding of both technical and content can help students deal with complex issues in the digital era nowadays [2]. Problem-solving is one of the skills that students must develop to meet the digital era in addition to critical thinking skills, creativity, innovation, communication and collaboration [3].

Problem-solving is the focus of the school’s mathematics curriculum which in the learning process is expected to gain the experience to transfer and apply learned knowledge and skills to solve problems [4-6]. Regarding to that problem, skilled people solve problems to survive and to face the various issues in his life. In fact, the Government of Indonesia paid particular attention to the mathematical problem-solving skills shown in the 2013 curriculum where the ability of mathematical problem solving is one aspect of mathematical competence that is expected to be gained in the mathematics learning.

Bransford and Stein introduced an IDEAL problem solver consisting of five indictors including (1) identifying problems; identifying information, questioning, visualizing situation and making them
creative thinking opportunities to determine the next stages. (2) Defining the problem; organizing information and question, finding and selecting the necessary/essential information to answer the question provided. (3) Exploring solution; finding/creating possible strategies; pattern, table, or models to solve the problem. (4) Acting on the strategies; using numeracy, algebra or geometric capabilities to solve the problem given, and (5) looking back and evaluate; rechecking answer, determining alternative solutions, discussing and developing answer to other situations [7]. IDEAL is a strategy that can be used to describe the ability of thinking skills in the process of problem-solving [8].

This study aims to analyze the mathematical problem-solving skills about word problem of the linear program. The analysis of mathematical problem-solving skills in this research is based on the modification of IDEAL problem solver indicator. This research is used to investigate, categorize, and analyze student’s problem-solving skills about word problem of the linear program using IDEAL problem solver, which can be used as a basis tool to consider the learning improvement.

2. Research method
The research design is descriptive. The subjects of this research were fifteen 12th grade senior high school students in Grobogan who were selected by random sampling technique. These schools are chosen because they are considered to represent the average ability of high school student in Grobogan, which is shown from the absorption capacity of linear program material in the UN SMA 2016/2017. The average absorption capacity of linear program material has reached 39.32%. The students who are as research subjects are students with heterogeneous learning abilities. The variables of this research used the indicators which is adopted from IDEAL problem solver including the ability of students to identify problems, determine the purpose of the problem given, choose most appropriate solving strategies, complete the procedure, and recheck the obtained solution. Furthermore, interviews with students about problem-solving strategies have been done to answer questions in the form of a given story. A description of the modification of IDEAL problem solver indicators used in this research is shown in Table 1.

| No | IDEAL’s indicators | Description |
|----|---------------------|-------------|
| 1  | Identify Problem    | (a) Students write down known and needed information appropriately <br> (b) Students write down known and needed information but not quite right <br> (c) Students do not write down known and required information |
| 2  | Define Goal         | (a) Students write down correctly what is asked in the problems <br> (b) Students write what is asked in the problems but not quite right <br> (c) Students do not write down what is asked in the problems they ask |
| 3  | Explore Possible Strategies | (a) Students write down problem-solving plan (table/model/graph) appropriately <br> (b) Students write down problem-solving plan (table/model/graph), but not exact <br> (c) Students do not write down a problem-solving plan (table, model or graph) |
| 4  | Anticipate Outcome and Act | (a) Students implement the plan, write the answers and computations appropriately <br> (b) Students implement the plan, write down the answers and computations but not quite right <br> (c) Students do not implement plans, write answers and computations. |
| 5  | Look Back and Learn | (a) Student interprets the obtained final answer by making a correct conclusion <br> (b) Students interpret the obtained final answers by making conclusions but are inadequate <br> (c) Students do not interpret the obtained final answer by making conclusions |

Triangulation is used to confirm the validity of the data. Confirmation process of data validity is done by comparing information or test result data and interview. The stages of data analysis in this
study include: (1) giving test about word problems of the linear program to students; (2) analyzing of the test results; (3) conducting interviews with students of various skills; and (4) analyzing the interview result.

3. Results and Discussion
3.1. Results
The result of problem solving test on first and third problem by using IDEAL indicators show that 15 subjects can be categorized into three categories. They are good categorized which is 13%, poor categorized which is 47% and very poor categorized which is 40%, meanwhile, most subject are not able to analyze the second problem. Furthermore, a summary of each IDEAL problem solver indicator with a maximum score of 2 can be seen in Table 2.

Table 2. Percentage of mathematical problem solving ability based on IDEAL.

| IDEAL problem solver indicators | Analysis |            |            |            |            |
|---------------------------------|----------|------------|------------|------------|------------|
|                                 |          | The number of questions | Student’s score | Total score | Percentage | Qualification |
| Identify Problem                |          | 3          | 7          | 90         | 8%         | Very Poor    |
| Define Goal                     |          | 3          | 7          | 90         | 8%         | Very Poor    |
| Explore Possible Strategies     |          | 3          | 44         | 90         | 49%        | Poor         |
| Anticipate Outcome and Act      |          | 3          | 60         | 90         | 67%        | Enough       |
| Look Back and Learn             |          | 3          | 28         | 90         | 31%        | Very Poor    |

Table 2 shows a summary of student’s mathematical problem-solving skills from three given problems. In the first and third problems, the problems are found in indicators identifying problems; define goals item only reach 12%, look back and learn are categorized very poor by 28%. Meanwhile, indicators on exploring possible strategies and anticipate outcome and act were good categorized as either 72% or 83%. Figure 1 below presents the result of very poor category subject (LDF) on the first problem and in Figure 2 represents the result of poor category subject (BKJ) on the second problem.

![Figure 1. Test’s result of LDF on problem 1](image1)

In the first problem, the LDF subject does not write down the known information and questions asked. The subject does not write a mathematical model that can be formed to the problem. The subject assumes the maximum value that can be searched from the result of the intersection of two
constraint function equations. Students do not write down the results of interpretation of final answers or conclusions about the last answer given. Subsequently, the interview was conducted on subjects with very poor categories (LDF) to confirm the subject's responses.

Question 1a: Of all the problems given, have you identified and written down the information provided? Is all the information is needed to answer the story?

Answer (Very Poor): I did not write down the information provided, it might be useful to answer the question but I try to answer all the questions given.

Question 1b: Have you written down the goals or questions asked on the problems?

Answer (Very Poor): I did not write down all the questions asked.

Question 1c: What strategy do you do to solve first problem? Have you worked on a chosen strategy?

Answer (Very Poor): I use elimination and substitution, because to find the maximum value I have to find the value of $x$ and $y$. The value of $x$ and $y$ that I get is $(60,140)$

Question 1d: Is that just the $x$ and $y$ values you get? What conclusion do you get? Have you written the conclusion of the final answer to all the questions you got?

Answer (Very Poor): Yes, only one value of $x$ and $y$. I did not write any conclusion but I know what to look for; the maximum income. I also did not write the final conclusions of the questions given.

The Interviews were also conducted on subjects with good and poor categories. Written interview transcripts include indicators identifying problems, defining goals, and looking back and learning. These indicators are presented in three questions.

Question 1a: Of all the problems given, have you identified and written down the information provided? Is all the information is needed to answer the story?

Answer (Good): I write down the information given in the problems, and the information provided is needed to answer the problems.

Answer (Poor): I sometimes write, but sometimes not, maybe all the information is needed to answer the problems.

Question 1b: Have you written down the goals or questions asked on the problems?

Answer (Good): I wrote down what is asked on the problems.

Answer (Poor): I did not write what is asked, but I knew what was being asked.

Question 1d: Have you written the conclusion of the final answer to all the questions you got?

Answer (Good): Yes, I wrote down the conclusion of the final answer I have got, but not all the problems.

Answer (Poor): Sometimes I write the conclusion of the final answer, but do not know whether they are right or not.

In Figure 2, subject BKJ is able to analyze the location of errors of the presented work. The subject only analyzed the final answer of the task given without looking at the process of the given problem. Most of the subjects do the same analysis that they only see the final results that have been presented without looking back at the operation of the problem given.

3.2. Discussion
In general, the results show that the students are trying to solve the problems based on IDEAL problem solver indicators. Students have been attempting to explain the given word problem, although not all work is done correctly.

Students with a good category can often solve the questions correctly; even the obtained results are not optimal. Students with good category have been able to identify and write down the information provided accurately, although they are incomplete. Besides, good category students have also written down what is asked on the problems, writing down the problem-solving plan (mathematical models, graphs, tables) and their computations, and providing an interpretation of the obtained final answers.

Students with poor categories have tried to solve the word problems given, although they are less precise. Students with poor categories try to identify and write down the information provided and what is asked correctly, although they are incomplete. Students with poor categories have written problem-solving plan (mathematical models, graphics, tables) and their computations, but do not write the final interpretation of the obtained final answer.

Students with very poor categories have tried to solve the story problems given, although the results of the work presented are less precise. Other finding showed that there are students with very poor category who made conceptual error in the first problems. Students with very poor categories do not identify and write down the information provided and what is asked, they tried to write down problem solving plan (mathematical models, graphs, tables) and their computations, but do not write the final interpretation of the obtained final answer.

The phenomenon above is called by various factors. One of the factors in the problem-solving process is students’ way of thinking. The things that are shown from the results of the research are the facts that most of the students are not able to identify the problem and define the goal, which influence the interpretation result. One way that can be taken to overcome the student’s inability to identify problems is by doing a mathematical representation [9]. Through mathematical representation, students will develop their way of thinking in communicating mathematical ideas in various representations, making them easier to understand. Other than that, continuous training is required not only through routine exercise, but through learning process designed by the teacher that can help to find the right solution [10].

Learning process which become the pillar is used to construct student’s knowledge. Therefore, teachers should provide learning opportunities to the students to solve the problems [11]. In the learning process, choosing the right learning strategy is one of the important tasks for a teacher. Problem solving skills can be accessed through learning activities with appropriate learning strategies [12]. Learning strategy using contextual context is one of learning strategies that can be used to improve students' understanding concept in problem solving process [13, 14].

The process of choosing the right strategy of learning aims to develop a meaningful learning process, allows students to make flexible decisions in solving mathematical problems. Students with flexibility in problem solving will solve the problem with various strategies [15]. In addition to paying attention to the learning strategy, the teacher should provide deep reinforcement of the prerequisite material before starting the new material [16]. Mathematics teachers are expected to be able to create learning which is not only focuses on result, but also the process, so the teacher can give experience to the students to develop their knowledge and aims to improve their problem-solving ability.

4. Conclusion
The results of the analysis provide an illustration that student’s mathematical problem solving ability at high school level is not expected. The description of student’s ability to solve problem, can be seen that at high school level percentage, the student’s ability to identify problem reached 8%. It is classified in the category of very poor. The percentage of student’s ability to define the goal reached 8%. It is classified in the category of very poor. The percentage of student’s ability to explore possible strategies reached 49%, and it is classified in the category of poor. The percentage of student’s ability to anticipate outcome and act reached 67%, and it is classified in the category of enough. The percentage of student’s ability to look back and learn reached 31%
and it is classified in the category of very poor. Most of the students are unable to identify the problem and define the goal which influence the interpretation result. Mathematics teachers are expected to create learning, which is not only focuses on the result, but also the process, so the teacher can give experience to the students to develop their knowledge and aims to improve their problem solving ability. In addition, teacher should also pay attention to the reinforcement of prerequisite materials before starting new material. Through learning that focuses on the process, students will be able to make best planning to solve various problems.

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