

# High school student's mathematical modeling skills in open-ended learning

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## High school student's mathematical modeling skills in open-ended learning

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**Abstract.** This research is a descriptive study aims to determine the mathematical modeling skills of students after using the open-ended learning to algebraic arithmetic operations in class VII SMP Negeri 17 Palembang. The subjects of this study were grade VII.6 students of SMP Negeri 17 Palembang with 32 students. The learning process is adapted to the stages of the open-ended learning. On the student worksheet, the problem given is an open-ended problem. The researcher also uses problem-solving questions during the evaluation test. Data collected using tests. The results of this study indicate that the mathematical modeling skill of students in open-ended learning in class VII.6 in SMP Negeri 17 Palembang is categorized good with an average of 78.54%. Students who are still lacking in modeling mathematical problems because they still incorrectly understand the problem and draw up a problem-solving plan.

### 1. Introduction

Based on Permendiknas No. 22 of 2006, one focus or goal in learning mathematics is to solve problems that include the ability to understand problems, make mathematical models, solve problems, and interpret solutions [1]. Mathematical abilities that students must be able to master through mathematics learning, namely: (1) communication; (2) reasoning; (3) connection; (4) representation; (5) problem-solving [2]. Problem-solving is very important in mathematics, not only for those who will later learn or explore mathematics, but also to be applied to other fields of study and in everyday life [3]. One of the stages in problem-solving that can help students in solving problems is understanding problems and planning problem solving that leads students to make mathematical models [4]. The cycles of model construction, evaluation, and revision are valued in the light of befitting the professional practices of mathematicians and scientist as engineering [5]. Mathematical modelling as problem-solving from a modelling perspective does not insist that students get the correct answer [6]. The problem-solving ability of students in Indonesia is still relatively low, this is based on the results of the Program for International Student Assessment (PISA) test conducted by the OECD in 2015 which was conducted in 69 countries including Indonesia, which scored an average of 386 out of 500 grades average OECD and ranked 62nd out of 69 countries [7]. Also, based on the 2015 TIMSS (Trends International Mathematics and Science Study) study conducted in 50 countries, Indonesia received 397 out of 500 TIMSS average scores. The characteristics of the questions given by TIMSS to measure the ability of reasoning and problem solving, namely on the topics Number (number), Algebra (algebra), Geometry (geometry), and Data and Chance (data and opportunity), this shows that the ability of solving student problems in Indonesia is still low [8]. Traditionally, mathematical modelling tends to be associated with higher school pure and applied mathematics (geometry, algebra, calculus, etc.) to solve real-world problems [6]. Based on data on the results of the national junior high school exam the percentage of students who



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were able to answer correctly on algebra material was only 41.88%. The national examination results state that many students make mistakes in answering questions on algebraic material. In algebraic material, students need problem-solving skills and understanding of concepts to model mathematical problems to solve these problems [9].

In general, mathematics learning in schools is still characterized by teacher-centeredness, when the learning process of the teacher is more dominant than the students and also the questions given for the exercise are more routine which makes the student's reasoning ability in problem solving still lacking and the ability to think only at low levels [10]. The teacher has a role to improve the ability to solve problems with mathematical modeling in students can use the methods used, or by evaluating the form of making questions that support [11]. One of the lessons that can improve students' ability to solve mathematical problems with modeling is open-ended learning. Open-ended learning can provide opportunities for students to gain knowledge, experience to find, recognize and solve mathematical problems with a variety of strategies [12]. Open-ended learning can improve the ability to solve mathematical problems by modeling a problem because with this learning students are not required to memorize facts, but students are encouraged to be able to construct knowledge in students' own minds [13]. The problem given in this open-ended approach is non-routine open-ended problems [13 - 15]. The purpose of this study was to determine the mathematical modeling skills of students in open-ended learning on the arithmetic operations material in the form of algebra in class VII SMPN 17 Palembang.

## 2. Method

This research is a descriptive study that aims to determine the ability of modeling mathematical problems of students after using open-ended learning in class VII.6 SMPN17 Palembang. The subjects of this study were students of class VII.6 SMPN 17 Palembang, amounting to 32 people. This study consisted of 3 stages, namely the preparation phase, the implementation phase, and the data analysis stage. The instruments used in this study were students' worksheets using open-ended or open-ended problems, test questions, and lesson plans based on the stages of open-ended learning. Data collection techniques in this study were obtained from the test data. The test is used to see students' mathematical modeling abilities in solving problems after using open-ended learning. The test is done after two learning meetings.

## 3. Result and Discussion

This research was conducted 3 meetings, 2 meetings in the form of a learning process using student worksheets, and 1 meeting in the form of tests. Researchers conduct open-ended learning activities consisting of 5 stages, namely (1) presenting the problem, (2) exploring the problem, (3) recording student responses, (4) discussing student responses, and (5) guiding students to summarize the lesson. In the implementation of learning the first meeting, and the second begins with an introduction, namely greeting, praying, asking for news, and checking the presence of students, conveying the learning objectives to be achieved after learning, and providing motivation in the form of the importance of learning algebraic arithmetic operations, and presents material regarding the arithmetic operations of algebraic forms. Then in the stage of presenting the problem, students are divided into 8 study groups consisting of 4 people. Researchers distribute students' worksheets that contain open problems that can be solved with various solutions or various answers, and also with the stages of problem-solving. In the stage of exploring a problem, researchers provide direction and explanation to students about supporting information in a brief, as well as activities or steps to solve the problems contained in the worksheets of students. Students are asked to understand the problem and ask if they still don't understand the information on the student worksheet. Then, students discuss and carry out various activities to solve the problem. At the stage of recording student responses, each representative from each group was asked to present the results of the completion obtained. Researchers observe and pay attention, the response of each group and who provide responses to answers or ways of resolution obtained by other groups. At the stage of discussing student responses, the researcher together with students discusses the answers and methods of resolution obtained by each group. At the stage of summarizing the lesson, the researcher guides the students to make conclusions about the count operations material on the algebraic form that has been learned. After that, the researcher closes the lesson by asking students to learn the next material,

and say hello. Overall in each meeting, the learning stages are carried out the same, which differs only in the material being studied. At the first meeting studying the material operations of addition and subtraction on the algebraic form. Meanwhile, at the second meeting studying the material multiplication and division operations on algebraic forms.

In the implementation of learning, to be able to solve the problems given on the student worksheets students can use the stages of problem-solving that are understanding the problem, planning problem solving, solving problems, and re-checking the results obtained. The following answers from students regarding the problems on the worksheets of students provided:

*Penyelesaian :*

$$\begin{array}{l} \text{Dik: } 3a + b = 60 \\ \quad a \times b = 225 \\ \Rightarrow 2a + b = 60 \\ \Rightarrow b = 60 - 3a \end{array}$$

$a = \text{bilangan Pertama}$   
 $b = \text{bilangan kedua}$

**Figure 1.** Answer the worksheets of students who are already appropriate.

From Figure 1, it can be seen that students can understand the problem and draw up a plan for solving it by making a mathematical model of a good and appropriate problem. Based on the existing problems students consider the first number with the letter  $a$ , and the second number with the letter  $b$ . Then, the information that is known is modelled into a mathematical form  $3a + b = 60$  and  $a \times b = 225$ . This shows that overall students have been able to change mathematical problem-solving problems in the form of modeling.

However, there are still some students who have not been able to model a problem into mathematical form. Here are the answers of students who are still mistaken in modeling mathematical problems:

$$\begin{array}{l} 3) \quad 3x + x = 60 \\ \quad 4x = 60 \\ \quad x = \frac{60}{4} = 15 \\ * \quad 3(15) + 15 = 60 \\ * \quad 15 \times 15 = 225 \end{array}$$

**Figure 2.** Answer worksheets of students who are still wrong.

From Figure 2 proficiency level, it can be seen that students mistakenly changed or modelled the problem in mathematical form. Students assume the first number and the second number with the same variable,  $x$ . Then, students immediately add up the algebraic form obtained and get the  $x$  value. This can occur because students are still mistaken in understanding the problem given and preparing a problem-solving plan. It has been acknowledged that students' initial conceptions developed during the modelling process could be characterised by unwarranted assumptions or the imposing of inappropriate constraints [16].

After the test is carried out, the test result data that has been obtained are analysed to find out the mathematical modeling abilities of students. The test results obtained are then examined and given a score based on the scoring guidelines that have been made by researchers. Next, the researcher determines the category of mathematical modeling abilities possessed by students which are very good, good, satisfactory, poor, or very poor. Table 1 shows categories of students' mathematical modeling skills.



**Table 1.** Categories of mathematical modeling skills of students.

Score Interval	Category
81-100	Very good
61-80	Good
41-60	Satisfactory
21-40	Poor
0-20	Very poor

Based on the answers to the test questions written by students, by modeling the problem in the form of mathematics, it seems that overall students can understand and plan the solution to the problem given. The following answers to the test questions obtained by students:

3) Dik: Lia menyukai 3 bilangan  
misalkan a, b, dan c  
 $a + b = 28$   
 $b + c = 42 \rightarrow b = 42 - c$   
 $a + c = 56 \rightarrow c = 56 - a$   
 Dit:  $a + b + c = \dots ?$

**Figure 3.** Answers to the test questions student's model mathematical problems.

From Figure 3, it can be seen that students correctly identify and write down what is known from the questions given. Then, students can also identify and write what is asked from the problem correctly. Assumptions made by students are clearly defined and supportive in making mathematical models of these problems. Furthermore, the variables identified by students are clear, and the models made by students are appropriate and appropriate. This shows that students can model problems into mathematical form. Thus, the answers and final solutions obtained by students are correct because students understand the problem and draw up a plan for solving it by modeling the problem into a good and appropriate mathematical form.

Nomor 3:  
 Dik: tiga buah bilangan disukai Lia  
 - Jumlah dari masing-masing ketiga bilangan 28, 42, dan 56  
 Ditanya: tentukan jumlah ketiga bilangan tersebut  
 Jawab:  $a + b + c = a + (42 - c) + (56 - a) \quad b = 42 - c$   
 $= a + 42 - c + 56 - a \quad = 42 - 3c$   
 $= 0 + 98 - c \quad = 7$   
 $(a + b) + c = 98 - c$   
 $28 + c + c = 98$   
 $2c = 98 - 28$   
 $2c = \frac{70}{2} = 35$   
 $a + b = 28$   
 $a + 7 = 28$   
 $a = 28 - 7$   
 $= 21$   
 $a + b + c = 35 + 7 + 21 = 63$

**Figure 4.** Answers to student test questions that are still incomplete in modeling the problem.

Based on Figure 4, the student with the right to write what is known and asked of the matter. The assumptions made and the variables used by students not defined and clearly identified, but according

to the given problem. However, students directly substitute values of  $b$  and  $c$  of the mathematical modeling that the students in the problem solving process.

Based on the results of the final test, the average student's mathematical modeling skills capability can be categorized either VII.6 i.e. 78.54. Students are considered to have very good modeling capabilities as many as 14 students with a percentage of 43.75%. Students are considered to have good modeling capabilities as much as 9 students with a percentage of 28.13%. Students are categorized modeling capabilities satisfactory as much as 7 students with a percentage of 21.87%. As well, students are considered to have poor modeling capabilities as much as 2 students with a percentage of 6.25%. The table below illustrates the percentage of students' mathematical modeling capability tests on the material form of algebra:

**Table 2.** Percentage test students' mathematical modelling capabilities

Frequency	Percentage	Category
14	43.75%	Very good
9	28.13%	Good
7	21.87%	Satisfactory
2	6.25%	Poor
Average	78.54%	Good

Based on Table 2, it can be said that most of the students have been able to model mathematical problem since learning of open-ended at the stage of exploring the issue of students accustomed to resolving problems by first writing down what is known and asked of the information provided and then make a mathematical model of the problem, but there are still some students who are confused and have trouble making a mathematical model due to not understand the intent of a given problem. In accordance with [17] that said open-ended learning can improve students' problem-solving skills including modeling the mathematical problem because with this approach makes students become actively involved in solving the problem, from the research data obtained 60% of students who have the ability to model mathematical problems in solving categorized problems both in learning with an open-ended learning. Mathematical modeling should be and could be started early, when students already have basic competencies then modeling can be developed [18, 19]. Mathematical modeling should be taught in every level of mathematics education [20].

#### 4. Conclusion

Based on research data obtained from VII.6 class at Junior High School 17 Palembang, it can be concluded that the mathematical modeling capabilities of students in open-ended problem solving to solve problems considered good. Students are used to model a problem into mathematical form due to the learning process students are given the open questions that require students to understand the problem and devise a plan that directs students' problem solving to model the mathematical problem.

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