

# High school students' mathematical modeling skills in problem-based learning (PBL)

*by Ade Muharani*

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## High school students' mathematical modeling skills in problem-based learning (PBL)

A R Sakinah<sup>1</sup>, C Hiltrimartin<sup>1\*</sup>, Y Hartono<sup>1</sup>, and Indaryanti<sup>1</sup>

<sup>1</sup>Mathematics Education Department, Universitas Sriwijaya, Palembang, South Sumatra, Indonesia

\*Corresponding author's email: [hiltrimartincecil@yahoo.com](mailto:hiltrimartincecil@yahoo.com)

**Abstract.** This study aims to know the mathematics modeling skill in Problem-based learning (PBL) in high school. Data were collected by test method in Students grade 10 SMA Negeri 2 in system of linear equation in three variable material. Based on the results of the research analysis, 64.7% of categorized learners have excellent modeling skills, 32.5% of the categories are good and 2% are poor. That is because students do not understand the problem, even though one of the goals of mathematics learning is students can solve mathematical problems which are covered by understanding problems and modeling problems into mathematical form. To realize these learning objectives the use of appropriate learning models is an important aspect. One learning model that can be used so that students have good modeling skill is Problem-based learning (PBL). PBL has a focus learning on contextual problems, so students can understand the problem and able to make mathematical models of the contextual problems presented.

### 1. Introduction

Based on Act number 2002/2003 about the national education system, it is written that national education functions to develop the ability, character building, and dignified civilization of the nation in the context of the intellectual life of the nation [1]. The purpose of national education is to develop the potential of students to become human beings who believe in and fear god almighty, knowledgeable, healthy, noble, capable, independent, creative and become responsible citizens [2], while in learning mathematics, one of the learning goals in school is that students are able to solve mathematical problems which include the ability to understand problems, design mathematical models, solve mathematical models, and interpret the solutions obtained [3].

To achieve these objectives, students are expected to show an understanding of the problem, organize data and choose the right information in problem-solving, present a problem mathematically in various forms, choose and develop problem solving strategies appropriately, have good problem solving abilities, interpret and modeling problems in mathematical form, and solving problems that are non-routine [4]. One method that is considered appropriate to help students understand and solve problems is using mathematical modeling [5]. Mathematical modeling is an activity of translating a contextual problem into a mathematical form, solved and redefined to explain the real problem [6]. It's important component in all areas in mathematics education [7]. Modeling skill is the ability of students to translate a contextual problem in everyday life into mathematics [8]. Mathematical modeling is very important in mathematics learning because to learn the problem of abstract students is directed to the real thing [9]. The modeling process includes understanding the problem, simplifying the problem by creating a contextual model of the problem, the mathematical stage that is changing the contextual problem to a mathematical model, working mathematically, interpreting the results of the mathematical model to real



results, then ensuring the results obtained, and describing the results obtained with an explanation [10]. In mathematical modelling there are frame work, such as: describing the real world problems, specifying the mathematical problem, formulate the model, solve the problem, interpret solution, evaluate the models, and report the solution [11]. Modeling process aims to simplify a problem so that it is more easily understood by students [8]. One of mathematical modelling is mathematically, it's a process to change the real model into mathematics [12]. The most difficult and crucial step is the first step in mathematical modelling. It formulate the problem to mathematical problem [13].

Based on the results of the current study there are many problems in education in Indonesia, so learning objectives are difficult to achieve, one of which is the ability of mathematical modeling. The low ability of modeling, especially in the field of mathematics in Indonesia can be seen based on the results of the PISA study. The results of the 2015 PISA study showed that Indonesia ranked 63 out of 72 participating countries [14]. Therefore, so that students can understand, model and solve problems as well as the realization of the objectives of learning mathematics it is necessary to have a learning model. One learning model that can be used to encourage students to have good modeling skill is Problem-based learning (PBL). The Problem-based learning (PBL) learning model has a focus of learning on the specified problem so that students not only learn the concepts related to the problem but also study the scientific method of problem-solving [15, 16]. It also allows students to find problems that are around them that can be used as problems in the learning process, as well as allowing students to think about solving these problems through discussion. Problem-based learning can make students identify problems, obtain causal relationships and apply concepts that fit the problem. The characteristics of problem-based learning (PBL) model are to educate students in solving a problems, the teacher as a facilitator in helping students to achieve the goals, provide new information and demand students produce a product such as transcripts, reports, and videos that explain solutions to the problem being discussed, and students are trained to be responsible so that if there are questions students can answer and explain supported by valid evidence [17]. The process is done by students through discussion so that they can convey ideas and opinions in the group. Thus, Problem-based learning (PBL) makes students happier so that learning becomes more meaningful [18].

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## 2. Method

This research uses descriptive research method which aims to describe the mathematics modeling skill in PBL in senior high school on system of linear equation in three variable material with the subject of the research is students grade 10 SMA Negeri 2 Palembang. The study was conducted with the following procedures: the first meeting was presenting students work sheet 1, the second meeting was presenting students work sheet 2 and the last meeting was conducted a test to see students' understanding in solving mathematical modeling problems.

## 3. Result and Discussion

### 3.1. Figure of students work sheet1 analysis results

Figure 1 shows the results of data obtained from students work sheet 1. In conducting students work sheet 1 research, the learning process is carried out using the problem-based learning model. The following problems are given to students work sheet:

*Mr. Heri is a property entrepreneur. In completing his work, Mr. Heri is assisted by his wife and his children namely Rina and Mrs. Tina. They are able to complete all work for 10 hours, whereas if Rina works with Mrs. Tina able to complete work within 15 hours. After 5 hours of working together, Rina had to go to campus. Mr. Heri and Mrs. Tina need an additional 10 hours of work to complete their work. Determine the time required for each of these three people if they work individually!*

In Figure 1 it can be seen that students are wrong in turning problems into mathematical forms. From the problems that exist students learn about the subjects (Mr. Heri, Mrs. Tina, Rina) become a variable not a lot of time required by the subject. Student error in modeling the problem is because students do

not understand the given problem. Based on the results of existing studies show that, mistakes students change the form of problems into mathematical models and understand the problem [16, 19].

- Dari permasalahan di atas, diketahui mereka mampu menyelesaikan seluruh pekerjaan selama 10 jam. Bagaimakah bentuk persamaannya?

Handwritten work showing the derivation of a sum of reciprocals equation:

$$\frac{1}{x} = \text{Pak hari}$$

$$\frac{1}{y} = \text{Bu Tia} \Rightarrow \frac{1}{x} + \frac{1}{y} + \frac{1}{2} = \frac{1}{10}$$

$$\frac{1}{z} = \text{Rina}$$

**Figure 1.** The results of the analysis of student's answers to students work sheet 1.

### 3.2. Figure of students work sheet 2 analysis results

Figure 2 shows the results of data obtained from students work sheet 2. In conducting students work sheet 2 research, the learning process is carried out using the problem-based learning (PBL) model. the following problems are given to students work sheet:

*Mr. Pandir has a beef cattle farm, every day Mr. Pandir feeds his cattle with a mixture of three different types of feed, namely grass, rice bran and rice. The price of feed per bag in a row is Rp 80,000.00; Rp.120,000.00 and Rp 150,000.00. Mr. Pandir needs 40 sacks of these three daily mixtures. The use of grass feed is twice as much as rice bran, while the funds provided for animal feed are Rp 4,300,000.00. How many sacks of each type of feed does Mr. Pandir have to buy?"*

Handwritten student work for a word problem involving feed mixtures:

• Informasi apa yang kamu ketahui dari permasalahan yang telah kamu baca

Dik: banyak rumput (karung)  $\rightarrow x$   
 banyak bekatul  $\rightarrow y$   
 banyak dedak padi  $\rightarrow z$

harga rumput = 80.000  
 harga bekatul = 120.000  
 harga dedak padi = 150.000 } 40 karung  
 total = 4.300.000

Dari permasalahan di atas, diketahui Pak Pandir setiap hari membutuhkan campuran ketiga pakan tersebut sebanyak 40 karung. Bagaimanakah kamu menuliskan persamaannya?

$$x + y + z = 40 \quad (1)$$

**Figure 2.** Results of analysis of student's answers on students work sheet 2.

In Figure 2 it can be seen that students are not mistaken in changing problems into mathematical models. Students can solve problems well, it proves that students understand the problems presented and can model problems into mathematical form. Mathematical modeling is a process of describing or representing contextual problems to find a solution and understanding the problems [13, 16].

### 3.3. Figure of test results

Figure 3 shows the results of the data obtained from the test. The following problems are given in the test:



Three even numbers have an average of 32. The second number plus 40 is equal to the number of other numbers, the plus number is equal to the number of other numbers minus 8. Determine the three numbers!

Dik: - Bilangan pertama = a  
- Bilangan kedua = b  
- Bilangan ketiga = c  
Dit: a, b, c ?

\*  $a + b + c = 3$  (1)

\*  $40 = a - b + c \rightarrow a - b + c = 40$  (2)

\*  $c = a + b - 8$   
 $8 = a + b - c$   
 $a + b - c = 8$  (3)

Eliminasi (1) & (2)

$$\begin{array}{r} a + b + c = 32 \\ a + b - c = 8 \\ \hline 2c = 24 \\ c = 12 \end{array}$$

Eliminasi 1 & 2

$$\begin{array}{r} a + b + c = 32 \\ a - b + c = 40 \\ \hline 2b = -8 \\ b = -4 \end{array}$$

Substitusi

$$\begin{array}{r} a + b + c = 32 \\ a + (-4) + 12 = 32 \\ a + 8 = 32 \\ a = 32 - 8 \\ a = 24 \end{array}$$

Jadi: a = 24, b = -4, c = 12

Figure 3. Student test results are wrong in modeling the problem.

In Figure 3 it can be seen that students mistakenly translate the problem presented. This shows that students do not understand the problem, and can't building a model, so they are unable to model the problem in mathematical form. The process of building a model from real world problem is a saturated task [19, 20].

Dik: - Bilangan pertama = a  
- Bilangan kedua = b  
- Bilangan ketiga = c  
Dit: Tentukanlah ketiga bilangan tersebut.

Jawab:

\*  $\frac{a + b + c}{3} = 32$   
 $a + b + c = 96$  (1)

\*  $b + 40 = a + b + c$   
 $40 = a - b + c$  (2)

\*  $c = a + b - 8$   
 $8 = a + b - c$  (3)

\* Eliminasi 1 dan 2

$$\begin{array}{r} a + b + c = 96 \\ a - b + c = 40 \\ \hline 2b = 56 \\ b = 18 \end{array}$$

\* Substitusi

$$\begin{array}{r} a + b + c = 96 \\ a + 18 + 44 = 96 \\ a + 62 = 96 \\ a = 96 - 62 \\ a = 34 \end{array}$$

\* Eliminasi 1 dan 3

$$\begin{array}{r} a + b + c = 96 \\ a + b - c = 8 \\ \hline 2c = 88 \\ c = 44 \end{array}$$

Figure 4. Student test results that can model the problem.

Figure 4 shows students who can model the problem. This shows that students understand the problem, so they can model the problem and solve the problem appropriately.

#### 3.4. Table of modeling skill categories

Table 1 shows the categories of mathematical modeling abilities. Modeling skills of students can be categorized [14] as having very good, good, satisfactory, poor, and very poor. The breakdown of these categories can be seen in Table 1.

Table 1 shows the categories of students' modeling abilities. Students with a value of  $80 \leq T \leq 100$  have excellent modeling skills,  $60 \leq T < 80$  are categorized as good,  $40 \leq T < 60$  are satisfactory,  $20 \leq T < 40$  have less modeling skill, and  $0-20$  have very less modeling abilities [21].

**Table 1.** Category of modeling skill

Interval	Category
$80 \leq T \leq 100$	Excellent
$60 \leq T < 80$	Good
$40 \leq T < 60$	Satisfactory
$20 \leq T < 40$	Poor
$0 \leq T < 20$	Very Poor

Table 2 shows the test results of 34 students who took the mathematics modeling skill test in learning Problem-based learning (PBL) on the system of linear equation in three variable material are as follows.

**Table 2.** Modeling skill test results

Percentage	Assessment Category
64.70%	Excellent
32.35%	Good
0%	Satisfactory
2.95%	Poor
0%	Very Poor

Table 2 shows that as many as 64.70% of students have excellent modeling skills, 32.35% have good modeling skills and 2.95% have modeling skills in poor category. Based on the research results obtained, students who understand the problem, have good modeling skills so that they can solve mathematical problems appropriately, while students who do not understand the problem, are more difficult in translating problems into mathematical form so that students have difficulty in solving and solving problem.

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#### 4. Conclusion

Based on the results of research in students grade 10 in SMA Negeri 2 Palembang, it is known that from 34 students who took the test, as many as 64.70% had modeling abilities categorized very well in PBL learning, whereas students with modeling abilities that were categorized as poor as much as 2.95%, it is because students can't understand the problem so they are unable to model the problem in mathematical form. In learning Problem-based learning students are focused on the problem, so students have the opportunity to better understand the problem. With good understanding, students can model problems into mathematical form.

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