

PAPER • OPEN ACCESS

Mathematical modeling learning design using Model-Eliciting Activities (MEAs) approach to two variable linear equation system material

To cite this article: N Pitriana *et al* 2020 *J. Phys.: Conf. Ser.* **1470** 012021

View the [article online](#) for updates and enhancements.

You may also like

- [The effect of ethanol extract of pasak bumi \(*Eurycoma longifolia* Jack.\) on neurogenesis and neuroinflammation of rat post protein malnutrition](#)
D D Sanyoto, Triawanti and M S Noor
- [Moringa oleifera milk powder as a supplementary food for malnutrition children \(SUSUKE\)](#)
S W Djoko, E Kembauw and I B D Kapelle
- [Integrated assessment of global climate, air pollution, and dietary, malnutrition and obesity health impacts of food production and consumption between 2014 and 2018](#)
Christopher S Malley, W Kevin Hicks, Johan C I Kulyenstierna *et al.*



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Mathematical modeling learning design using Model-Eliciting Activities (MEAs) approach to two variable linear equation system material

N Pitriana, Darmawijoyo and E Susanti

Mathematic Education Department, Sriwijaya University, Palembang, Indonesia.

Email: nyla_fitrianas@yahoo.com

Abstract. This study aims to produce a trajectory of mathematics modeling learning with the context of Malnutrition in Indonesia using Model-Eliciting Activities (MEAs) approach in the of two-variable linear equation system material. In mathematics modeling classes, students learn to solve real problems using mathematical procedures and concepts. The method used is a study validation type research design that aims to prove learning theories. This research design consists of three stages; preliminary design, teaching experimentation, and retrospective analysis. The subjects of the study are Grade VII students of Public JHS 21 Palembang. Data collection techniques used are video recording, interviews, and documentation. Data were analyzed by comparing Hypothetical Learning Trajectory (HLT) and what happened during the learning process. This research produces a learning path of mathematical modeling using Model-Eliciting Activities (MEAs) approach with the context of Malnutrition in Indonesia in the two-variable linear equation system material. The results of this study indicate that through a series of mathematical modeling activities using Model-Eliciting Activities (MEAs) approach can help students in understanding two-variable linear equation system material. Keywords: Mathematical Modeling, Malnutrition in Indonesia, two-variable linear equation system, MEAs.

1. Introduction

Based on the results of the PISA assessment conducted from 2000 to 2012, it showed that Indonesian students occupy the 65th or lowest position in PISA (OECD, 2013). On mathematical literacy in 2000, 2003, 2006, 2009, and 2012, Indonesia ranks 10th lowest among the PISA participating countries (OECD, 2013). One of the factors is the ability to solve the problem of linear equation systems, many students have difficulty in making mathematical models, errors in completing mathematical models, and errors in stating the final answers to problems (Wijaya and Marsiyah, 2013), lack of flexibility in using strategies to solve equation (Khuluq, et al. 2015), students are wrong in determining what is known, determining what is stated, and in making mathematical models, and students are wrong in performing algebraic operations to solve the problem (Kurniawan 2007).

A two-variable linear equation system is a system consisting of two linear equations that have two variables (Ortner, Jerry 2010). Two variable linear equation system is an equation with two variables that form a straight line graph (Van de Walle, 2007). The two-variable linear equation system is one of the subjects used in everyday life, for example age, money, investment, buying and selling and business, from the learning outcomes of a two-variable linear equation system using Online Shop context or buying and selling using electronic media shows that students are easier to understand and able to explain the meaningfulness of the value of the variables obtained (Susanti, et al 2016).



The two-variable linear equation system is one of algebraic material. The method used in solving equations is to use a two-container scale model and mathematical modeling (Van de Walle, 2007). To make it easier for students to learn the system of two-variable linear equation, we need to link student experiences in real world life as is done in everyday life (Blum, 2009). In mathematical modeling, to make it more interesting and connect it to social life, it takes the role of context, because mathematical modeling is the process of changing or representing problems in the real world into mathematical form in an effort to find solutions to a problem (Ang2009).

Mathematical modeling is very interesting because it is used in everyday life, even outside mathematics including nature, society and other scientific disciplines (Blum, 2009). Mathematical modeling is also an important part of learning in which there are mathematical subjects namely science, technology, and engineering (Lowe, et al, 2018). Mathematical modeling is also used as a process of solving real-world problems (Brown, 2015).

Based on the results of research, problem solving using mathematical modeling can increase the average value of students (Fauziah, et al 2017). In other studies, mathematical modeling is effective in improving students' argumentation and abilities (Wulandari, et al. 2016). Learning using mathematical modeling also shows that learning outcomes and student motivation are better (Selvia, et al 2014). And with mathematical modeling, it can improve student understanding in a structured way (Turmudi, Dkk 2014).

Mathematical modeling is different from others because (1) Explicit attention at the beginning of the process of obtaining it is from problems outside mathematics for its mathematical formulation, and (2) Explicit reconciliation between mathematics and real world situations and at the end of modeling completion, results must be mathematically appropriate and suitable in a real world context (Pollak, 2003). Mathematical modeling is different from others because it focuses on structural characteristics (Lowe, et al, 2018).

In this study, we want to review the results of research that has been conducted in learning mathematical modeling using Model-Eliciting Activities (MEAs) approach to the health context, namely the problem of malnutrition that occurs in Indonesia on the material system of two-variable linear equation. In mathematical modeling, the problem studied must be a problem that actually occurs in everyday life. So it has meaning in the process of completion. The hope is that when this problem is meaningful to solve, it will be an attraction for students to learn it.

The problem of malnutrition related to the two-variable linear equation system is about the balance between the amounts of food that must be consumed with the amounts of food needed by the body. It's important to pay attention to the balance between the food consumed and the food needed by the body every day. Because if this problem is not observed, it can lead to malnutrition or obesity. In this study, an example of malnutrition caused by food consumed daily is about the amount of carbohydrates and protein consumed with the number of calories needed every day. To balance the number of calories consumed with the number of calories needed by the body, this problem can be solved by a two-variable linear equation system.

The weight of food consumed is assumed to be the coefficient. The type of food consumed is assumed to be variable. And the amount of weight of food consumed is assumed to be a constant. After this problem is solved, using mathematical calculations, it is obtained how many calories must be consumed, to match the number of calories needed by the body every day. Mathematical modeling becomes one of the real solutions to the problem of malnutrition that actually occurs in everyday life. So that this problem can be categorized in mathematical modeling, namely problems that begin with real world problems and end with real world solutions. As in Blum general taxonomy found in the image below.

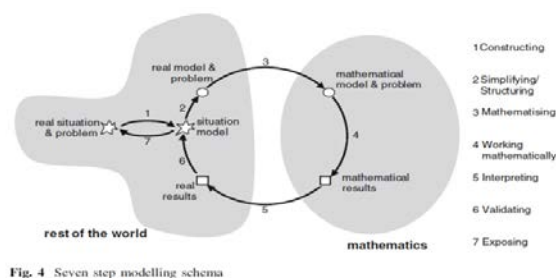


Fig. 4 Seven step modelling schema

Figure 1. Taxonomy Blum

According to Gimme, Mathematical Modeling is the process of using mathematics to represent, describe, predict, and provide insight into real world phenomena. Mathematical modeling is the process of getting an understanding of mathematics through real world contexts. Mathematical modeling is a process that uses mathematics to present, analyze, make predictions or otherwise provide insight into phenomena in the real world (Bliss and Libertini 2016).

From the explanation above, in this study I used mathematical modeling to facilitate students' understanding of concepts in learning the system of two-variable linear equation through three activities. The first activity is understanding the problem and making the thinking foundation. The second activity is making it into a mathematical form and then completes it. The third activity is interpreting the answers and reporting the results.

2. Research Methods

This study uses a design research method that designs mathematics modeling learning on two-variable Linear Equation System material. The design research method used is type validation studies that aims to prove learning theories (Akker, McKenny, and Nieven, 2006). This is the right way to answer the researcher's questions and achieve the objectives of the study. In addition, the main objective of design research is to develop a learning trajectory or HLT (Akker, 2006). In the implementation of design research there is a stage which is a repetitive process cycle from thought experiment to learning experiment (Gravemeijer, 1994). The research design consisted of several stages, namely preparing for the experiment, teaching experiment, and retrospective analysis (Bakker, 2004).

This research was conducted in the even semester of the academic year 2018/2019. The subjects of the study were Grade VII students of Public JHS 21 Palembang. In this case, class VII5, used as the subject of research in the preliminary design stage in one meeting includes 6 students with low, medium and high ability. In the preliminary design stage, the pretest questions are used to see the students' initial ability to comprehend the material of the Two-Variable Linear Equation System. Then to test the initial Hypothetical learning trajectory (HLT), 6 low, medium and high ability students were taken at the pilot experiment stage held in class VII8 for two meetings, while the subject to answer the problem in this study was conducted at the teaching stage. The experiment was class VII9 students, 2 meetings were conducted. In the class there were 30 students consisting of 13 boys and 17 girls.

This research went through three stages, namely the first preliminary design, the second is teaching experiment, and the third is retrospective analysis. In the initial design, there were interview and observation activities as well as designing the alleged learning path (Hypothetical Learning Trajectory). The HLT that was designed was tested on a pilot experiment (cycle 1) and a retrospective analysis was performed. The results of this analysis will contribute to the HLT revision then be applied to the teaching experiment (cycle 2). The process of learning activities in cycle 2 is analyzed again to improve the HLT which will be a learning trajectory. Because the purpose of Retrospective Analysis is to develop local instructional theory, therefore, in this case, the HLT that was made was compared with actual student learning. Then the results can be used to answer the problem formulations in this study.

2.1. The process of producing Local Instructional Trajectory (LIT)

The problem formulation of this study is how the learning trajectory of mathematical modeling with the health context using MEAs approach in the two-variable linear equation system material. Description of the learning trajectory is carried out starting from developing students' ability to understand problems, making rationale, making equations, making mathematical solutions, interpreting, concluding and describing the results obtained to solve problems (Bliss & Libertini, 2016). Activities using the health context in mathematical modeling conducted by students are from informal to formal knowledge, then back to informal.

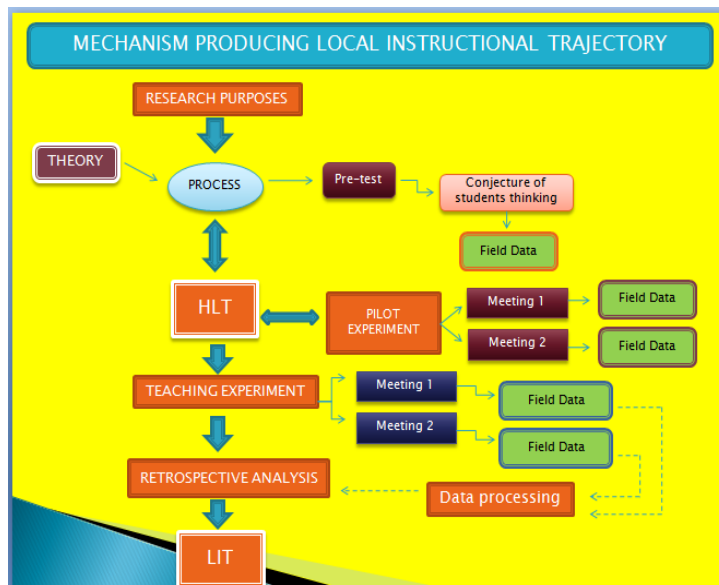


Figure 2. The Process of producing Local Instructional

2.2. Hypothetical Learning Trajectory (HLT)

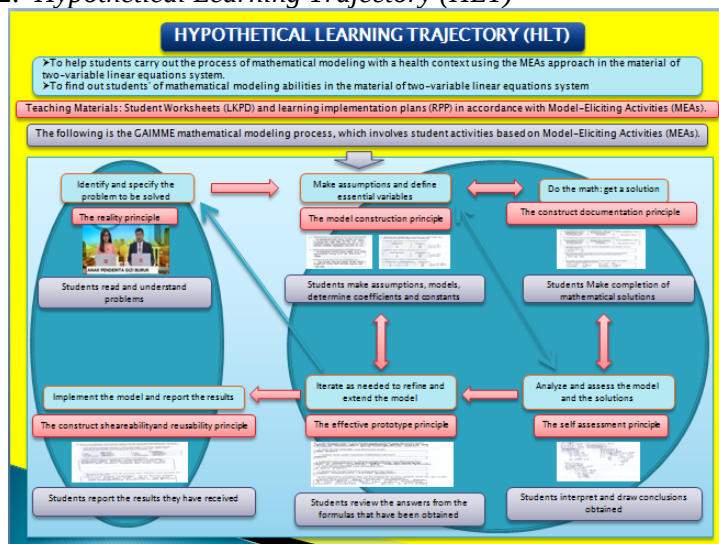


Figure 3. Hypothetical Learning Trajectory

In producing learning trajectories, the HLT Experiment stage that has been designed is tested in a non-experimental class. Then with some improvements, HLT was re-tested in the experimental class in two meetings. By viewing video recordings, observations, interviews, and documentation, researchers process data and analyze, after that, the learning trajectory can be used in the process of teaching and learning activities of students in the material system of linear equations of two variables.

In the process of making HLT, the things that are studied are the purpose of research, learning theory, and the alleged thinking of students. To see the students' alleged thoughts, the first stage is to look at the students' initial abilities by pre-testing the material system of two-variable linear equations. Then after the data is obtained, at this stage, researchers have designed a Hypothetical Learning Trajectory (HLT). This HLT is a series of Mathematical Modeling learning activities with a health context using the Model-Eliciting Activities (MEAs) approach in a Two-Variable linear equation system.

According to Simon 1995, HLT contains learning objectives, learning activities, and tools that can help the learning process to predict how students' minds and understanding will develop in the context of learning activities. Based on the steps in making the HLT above, the researcher developed HLT in

the form of a series of learning activities in Mathematical Modeling with a health context using Model-Eliciting Activities (MEAs) approach to the material system of two-variable linear equations.

2.3. Hypothetical learning trajectory (HLT) Experiments

HLT testing is conducted in two meetings, at this stage, researchers have designed Learning trajectory and hypothetical learning trajectory (HLT). HLT is a series of learning activities of the Two-Variable Linear Equation System using MEAs approach in mathematical modeling that includes learning objectives, learning activities, and hypotheses of the learning process to predict how students' minds and understanding will develop in the context of learning activities (Simon, 1995). Based on this, the researcher developed HLT in the form of a series of learning activities on the material system of two-variable linear equations using MEAs approach in mathematical modeling that contains guesses consisting of learning objectives, learning activities, and devices that can assist the learning process. These allegations serve as guidelines used as guidelines to anticipate students' thoughts and strategies that emerge and can develop in learning activities. These allegations are dynamic in nature that can be adjusted to students' reactions in learning and are revised during the teaching experiment.

2.3.1 HLT trial on the first meeting. In the first activity, the activities carried out were to understand real-world problems and to make a foundation of thinking about malnutrition in Indonesia. Based on the results of student activities in the first activity, students can solve problems correctly through the modeling steps designed. In activity 1 number 1, which is understanding the problem, questions are designed to guide students to question number 2, which is to create a foundation for thinking. In question number 2, the problem that students work on is about calculating how much weight the food that contains carbohydrates and how much weight the food that contains protein. The amount of weight of carbohydrates and protein eaten produces calories, i.e. 1 gram of carbohydrate contains 4 grams of calories and 1 gram of protein also contains 4 grams of calories. Most students answer correctly in determining the number of calories based on the modeling that has been made.

The second activity is to make equations (mathematical models) and mathematical solutions, students calculate the weight of food containing carbohydrates and the weight of foods containing protein in the form of a two-variable linear equation system. Students make a formula and make an equation then do a system calculation of two variables linear equation with the substitution method. Then students determine how many grams of carbohydrate and protein.

The third activity is interpreting, concluding and describing the results obtained to solve the problem of malnutrition in Indonesia. In this activity, students present conclusions in the form of the number of calories that must be met every day by men and women. They also counted the amount of carbohydrates and protein that must be consumed should not be more or less. To meet the body's calorie needs per day. Then students draw conclusions and present the results of the activities they have done in front of the class.

2.3.2 HLT trial on the second meeting.

In the first activity, which is identifying real-world problems about malnutrition in Indonesia which is acute malnutrition that occurs in Intan Zahar. Based on the results of students' work it was found that they were able to solve the problem correctly through the modeling steps designed. The first activity, is about the rationale, designed to guide students in the second activity, which involves problems that aim to calculate the weight of foods containing carbohydrates and the weight of foods containing protein. Carbohydrates and protein eaten produce calories, i.e. 1 gram of carbohydrate contains 4 grams of calories and 1 gram of protein also contains 4 grams of calories. Most students answer correctly in determining the number of calories based on the mathematical modeling steps that have been made.

The second activity is making mathematical equations and solutions. Students make formulas and make equations then do calculations with the substitution method. Then students determine how many grams of carbohydrate and protein.

The third activity is interpreting, concluding and describing the results obtained to solve the problem of acute malnutrition experienced by Intan Zahar. In the third activity, students present conclusions in the form of the number of calories that must be met by Intan Zahar every day. the amount of carbohydrates and protein that must be consumed must not be more or not less to meet the calorie needs of Intan Zahar per day. Then students make conclusions and present the results of activities that have been carried out.

In every activity that was carried out, the closure of learning is to present the results of the discussion or the activities that they did. Presentation activities provide opportunities for students to express their opinions and respect each other.

2.4. Data Collection Technique

Data collection techniques used in this study are:

- a. Pre-test and post-test: Pre-test aims to determine the level of initial understanding of students who are subjected to research and prerequisite material that they should have learned. This pre-test is done before the pilot experiment and teaching experiment. While the post-test is intended to determine the level of student understanding of the subject matter that has been given after the pilot experiment and teaching experiment process has been completed.
- b. Field Note: Field notes are made to support pre-test and post-test data, photo and video documentation, and interview results.
- c. Interviews: This interview will be carried out to different individuals and at different stages. Starting from the stage of making HLT to conducting research and teaching experiments.

2.5. Data Analysis Technique

Data analysis in design research was carried out qualitatively. The researcher together with the supervisor analyzed the data to improve the suitability of this study, which began with the preliminary design, pilot experiment, and teaching experiment stages. The data analysis technique used is:

- a. Reliability
 - 1). Internal reliability; conducted by collecting and reviewing audio and video recordings.
 - 2). External reliability is known as track-ability, which means that the reader must be able to track or trace the learning process of the researchers and to reconstruct their studies, recognize failures and successes, the procedures followed, the conceptual framework used, and the reasons for certain choices that are all must be reported.
- b. Validity
 - 1). Internal validity, refers to the quantity of data collection the level of validity of the reasons that led to conclusions. the data obtained comes from the results of recorded videos, student work, interviews, and field notes.
 - 2). External validity; also called generalizability. This validity concentrates more on the results given during the study.

3. Results and Discussion



Figure 4. The Reality Principle.



Figure 5. The Model Construction Principle.



Figure 6. The Self-Assessment Principle.



Figure 7. The Construct Documentation Principle.



Figure 8. The Construct Shareability and Reusability Principle

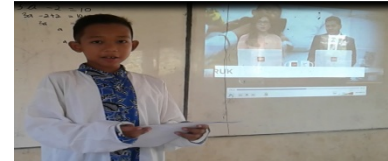


Figure 9. The Effective Prototype Principle.

In this study, the researcher used the context of HEALTH, which is about malnutrition in Indonesia. The health context that can be used in a two-variable linear equation system is a context related to the weight of food consumed which is called the coefficient, the type of food consumed that contains carbohydrates and proteins called variables, then the amount of carbohydrate weight plus the weight of protein consumed is called a constant. In general, men need 2,500 calories per day, while women need 2,200 calories per day. To meet calories per day, a two-variable linear equation system can be used to calculate the number of calories consumed with the calories needed by the body. In the context of health, namely the problem of malnutrition in Indonesia, it can be solved by using a two-variable linear equation system. The use of real-world contexts is in accordance with mathematical modeling strategies, namely the process of understanding, simplifying and solving real-life problems in terms of mathematics (Ang, 2009). Blum (2009) also added that mathematical modeling can support mathematics learning in terms of motivation, understanding, memory, and in terms of showing what mathematics is and how it can be used. Finally, the health context used is a context that can increase the significance of students in learning material related to the two-variable linear equation system.

This research produces a trajectory of learning mathematical modeling with the health context of the problem of malnutrition that occurs in Indonesia using Model-Eliciting Activities (MEAs) approach in the material system of two-variable linear equations. The results of this study indicate that through a series of mathematical modeling activities can assist students in understanding the material system of two-variable linear equation.

This study uses Model Eliciting Activities (MEAs) approach in the learning process. The six MEAs principles that have been implemented in the learning process are: (1) The Model Construction Principle. This principle states that the activities carried out by students to create a system or mathematical model in achieving the goal of problem solving. This can be seen when students make a mathematical model of a health problem that is about malnutrition in Indonesia with a mathematical solution that is a two-variable linear equation system. 2) The Reality Principle. This principle states that the problems presented should be realistic and can occur in the lives of students. The problems designed in this study use the health context, which is about malnutrition in Indonesia, so the problem used is a realistic problem, and meaningful to learn. (3) The Self-Assessment Principle. This principle states that students need information or various contexts that are used to help test their progress in solving a two-variable linear equation system. This is seen when students are able to find their solutions without the help of the teacher. (4) The Construct Documentation Principle. This principle states that in addition to producing models, students also express their own thoughts, namely during solving the problem of linear systems of two variables and from their thought processes must be stated as a solution. (5) The Construct Shareability and Reusability Principle. This principle states that the model developed must be able to be seen and developed and can be reused. With the health problems regarding malnutrition occurring in Indonesia that are presented, it can encourage students to develop a general model and can be used to overcome other similar problems. (6) The Effective Prototype Principle. This principle states that the resulting model must be easily interpreted by others. This principle helps students learn the material system of two-variable linear equations, that solutions applied to mathematical problems can be generalized.

The six principles above have been applied in learning mathematics modeling with health context using the MEAs approach to the material system of two-variable linear equations. First the teacher

begins by presenting the material and recalling past learning. Then students are grouped with 5-6 members per group. Then the teacher provides learning with mathematical modeling steps in the form of Student Worksheets. Students are ready for questions based on these problems. The teacher as a facilitator ensures that each group understands what is the problem and students try to solve the problem through the mathematical modeling process. Finally, students present their mathematical models after discussing and reviewing solutions.

3.1. Preliminary Design Results

3.1.1 Pretest

a. Problem number 1:

Solve the following problem!

A trader records the sale of Chicken and Catfish every day in different markets. In Perumnas market he can sell 14 kg of Chicken and 25 kg of Fish with the sale of Rp. 970,000 while in Yada market he could sell 25 kg of Chicken and 20 kg of Fish with the sale of Rp. 1,190,000.

Based on the problems above,

- Write down any information that is known from the problem!
- Make a mathematical form that states the relationship between how many chickens and fish sold with the money earned!
- How much is 1 kg of chicken and 1 kg of fish?

Figure 10. Problem number 1

The above problem is made based on the learning objectives that have been formulated, namely to see the mathematical modeling ability of students and to see whether students already understand about equations, make it into mathematical form and solve a two-variable linear equation system. The following are students' answers in solving question no. 1:

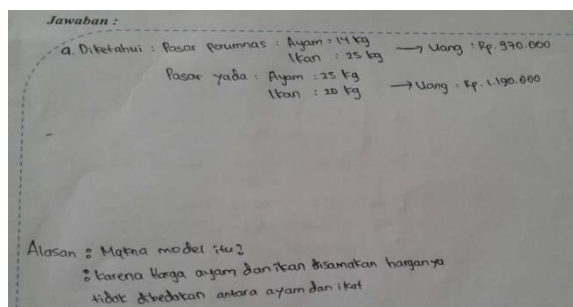


Figure 11. student A's answer to question number 1

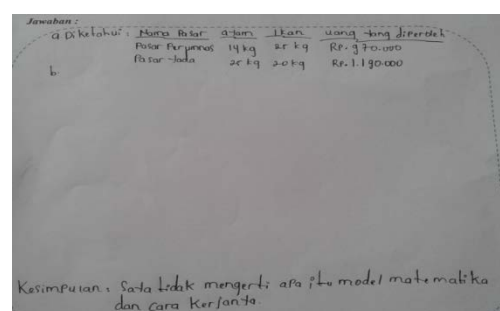


Figure 12. student B's answer to question number 1

Figure 11 shows that student A can answer number 1 part a and cannot answer parts b and c, he also gives a reason why he cannot solve the problem, he assumes that the price of chicken and fish is equal so they cannot find the price of 1 kg Chicken and 1 kg Fish.

Figure 12 shows that student B can answer question no 1 part a, but cannot answer part b and c, he also concluded that he did not understand the language of the mathematical model and how to do it, so he could not determine what the price of 1 kg of Chicken and 1 kg of fish.

b. Problem number 2

A parking attendant gets Rp. 17,000.00 from 3 cars and 5 motorcycles. While from 4 cars and 2 motorcycles he got Rp. 18,000.00. If there are 20 cars and 30 motorcycles, the parking money earned is

Figure 13. Problem number 2

The above problem, taken from the 2015/2016 National Examination aims to find out whether students are familiar with the two-variable linear equation system, make a mathematical model and to see the process they find a solution to the problem. The following answers students in solving questions no. 2.

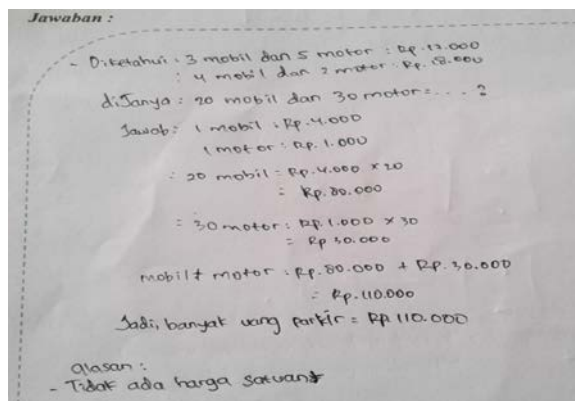


Figure 14. student A's answers to question number 2

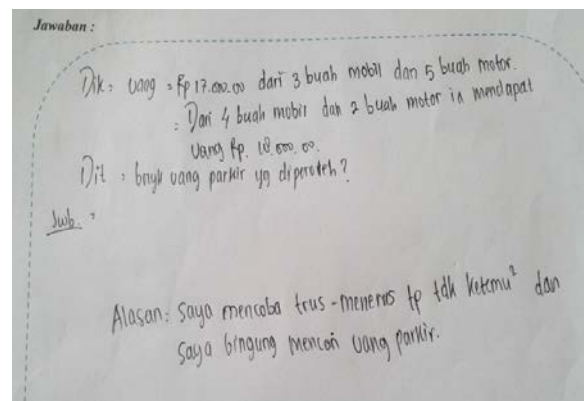


Figure 15. student B's answer to question number 2

Figure 14 shows that the student can answer the question correctly with his own question, that is by trying several times to get the results, he sums up and subtracts what is known about the problem so that he gets the right answer when substituted, there also shows that the student has not able to make a mathematical model so he gives a reason that there is no unit price. It can be seen that students have not been able to do the mathematical modeling process.

Figure 15 shows that students have not been able to make a mathematical model. So that students are confused to solve these problems, he also gives reasons for trying to continue but cannot find the results if substituted.

c. Problem number 3:

Given the equation system $3x-2y = 7$ and $2x + y = 14$, what are the values of x and y ?

Figure 16. Problem number 3

The above problem is made to find out whether students can work if the mathematical model is known. The following answers students in solving questions no. 3.

Figure 17 shows that students try to make that $x = 1$ and $y = 12$, so when added up the results are 14, and he is confused if the values of x and y are substituted and then it does not produce $= 7$, this means students have not been able to identify variables and make it into mathematical forms and solutions in mathematics. Figure 18 shows that students try to make that $x = 3$ and $y = 1$, so that when substituted they get the result $= 7$, but when substituting the values of x and y into equation two, the results are not obtained $= 14$ so that students feel confused with the value of x and y and the results of 7 and 14, this also shows that students have not been able to identify variables and make them in the form of mathematics and solutions or solutions in mathematics.

1. $2x + y = 14$
 $\rightarrow 2x + 12 = 14$

2. $3x - 2y = 7$
 $3x + 3 = 7$

Alasan = bingung mencari yg $3x - 2y = 7$.

Figure 17. student A's answers to question number 3

Jawaban :

$3x - 2y = 7$

3

Cara mengerjakan sistem persamaan dan nilai x dan y serta hasil angka 7 dan 14

Figure 18. student B's answer to question number 3

d. Early retrospective analysis test

In question number 1, no student answered correctly, the student only answered the question in a way that they thought could give the answer. This indicates that students have not been able to understand the problem well. Then in question number 2, students can answer the questions in their own way, but with a fairly long way and try several times to find the right answer. This also indicates that students have not been able to understand, identify, make models and find mathematical solutions to solve problems. Furthermore, in number 3 students no one can answer correctly, they only give reasons that show their confusion with the questions given.

From the results of this preliminary test, it was seen that students had difficulty in understanding the problem, making mathematical models and solving the system problem of linear two-variable equations. In the results of this preliminary test, it shows that students do not understand the steps in mathematical modeling of the system of linear equations of two variables, have not been able to determine variables, make mathematical models and solve them.

3.1.2 Pilot experiment result

Malnutrition in Indonesia
The problem of malnutrition in Indonesia is still very high. According to Lily, there are many factors that cause malnutrition in Indonesia. One of them is diet and food availability. (Tribunnews.com) General standard of calories needed by a person varies by sex, age, weight, physical activity, physiological activities, (for example pregnant women) and others. But in general, men need 2,500 calories per day. While women need 2,200 calories per day. (Kompas.com) Balanced nutrition includes food diversity, between food sources of energy substances (carbohydrates), namely staple foods, sources of building substances (protein) through side dishes, and sources of regulating substances through vegetables and fruits. (Kompas.com) 1 gram of protein equal to 4 calories and 2 grams of carbohydrate equal to 4 calories. (HaloSehat.com) For example, the specific gravity of 4 foods containing carbohydrates and 2 types of foods containing protein is 500 grams. While the specific gravity of 3 types of food containing carbohydrates and 4 types of food containing protein are 800 grams. How many grams per carbohydrate and protein?

Figure 19. Problem in pilot experiment

a. Activity 1

In activity 1, understanding the problem and making the foundation of thinking, students look fluent in working on the worksheet and do not look difficult at all.

The following answers students on the problem activity 1.

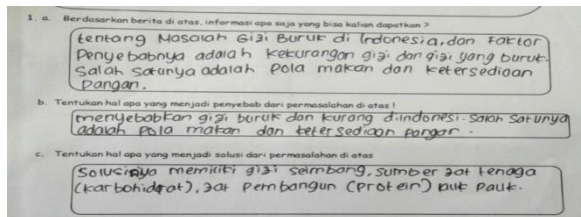


Figure 20. student 1's answers to activity 1

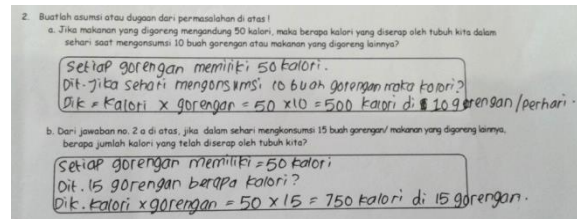


Figure 21. student 2's answers to question number 2 part a and b

In activity 1 no 1 namely understanding the problem, students are herded through questions contained in the news, they are led in understanding the problem in order to be able to answer questions that are asked about problems in daily life.

In activity 1 no 2, which is the ladder of thinking, students are guided through questions which later can lead to their mathematical models and understand the calories content found in foods that contain carbohydrates and protein. The following answers students activity 1 no 2.

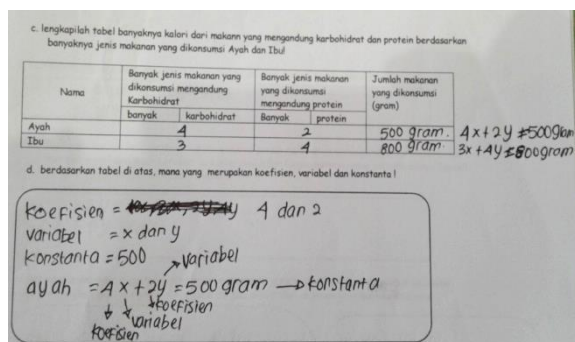


Figure 22. student 2's answers to part c and d activity 1

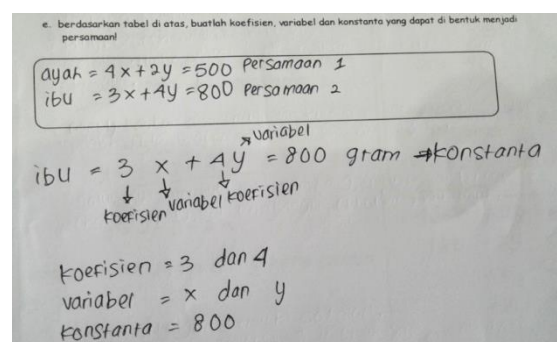


Figure 23. student 2's answer to part e activity 1

From number 2c above, students are led to make their mathematical models through tables and mention variables, coefficients and constants consumed by father and mother.

From number 2 e above, students can make a mathematical model with questions that have been made previously.

b. Activity 2

In activity 2, which is number 3, students make their mathematical models. The following answers students on the problem activity 2.

Aktivitas 2

3. a. berdasarkan hasil soal diatas, ubahlah variabelnya menjadi bentuk simbol (huruf)

Misal: x untuk karbohidrat
 y untuk protein

b. bagaimana bentuk matematika untuk menyatakan jumlah makanan yang mengandung karbohidrat dan makanan yang mengandung protein terhadap jumlah kandungan makanan yang dikonsumsi (gram)?
Gunakan simbol yang telah kalian tentukan!

$$\begin{aligned} 4x + 2y &= 500 \\ 3x + 4y &= 800 \end{aligned}$$

Figure 24. student 3's answers to part a and b activity 2

4. Berdasarkan dan contoh diatas dan persamaan matematika yang telah dibuat pada langkah sebelumnya, tentukan gram karbohidrat dan protein Ayah dan Ibu yang dikonsumsi dari makanan yang mereka konsumsi!

ayah = $4x + 2y = 500$ P.1
ibu = $3x + 4y = 800$ P.2

UNTUK MENGETAHUI NILAI x , maka cari nilai y terlebih dahulu dari persamaan 1

$$\begin{aligned} 4x + 2y &= 500 \\ 2y &= 500 - 4x \\ y &= \frac{500 - 4x}{2} \\ y &= 250 - 2x \end{aligned}$$

kemudian, masukkan nilai y ke persamaan 2

$$\begin{aligned} 3x + 4y &= 800 \\ 3x + 4(250 - 2x) &= 800 \\ 3x + 1000 - 8x &= 800 \\ -5x + 1000 &= 800 - 1000 \\ -5x &= -200 \\ x &= 40 \end{aligned}$$

ibu = $40(3) = 120$ karbo
= $170(4) = 680$ prote

Sebelum itu, masukkan nilai x ke persamaan 1

$$\begin{aligned} 4x + 2y &= 500 \\ 4(40) + 2y &= 500 \\ 160 + 2y &= 500 \\ 2y &= 500 - 160 \\ 2y &= 340 \\ y &= 170 \end{aligned}$$

Jadi, nilai $x = 40$
dan nilai $y = 170$
jadi, karbohidrat ayah (x) = 40
dan protein ibu (y) = 170
ayah = $40(4) = 160$ karbo
= $170(2) = 340$ prote

Figure 25. student 4's answers to activity 2

In Activity 2 no 3 a, students are given a question to lead to completion, namely by making symbols on the food consumed. Furthermore, number 3 b, students in the sleigh make a mathematical model that is in the form of a system of two-variable linear equations contained in the problem, can be solved using mathematical solutions, namely the material system of two-variable linear equations.

In activity 2 no 4, i.e. the solution in mathematical form. Students are given instructions and led in working on the two-variable linear equation system using the substitution method, so students can determine how many foods containing carbohydrates and protein have been consumed by Father and Mother.

c. Activity 3

In Activity 3, recheck the answers and find a solution. The following answers students on the problem activity 3.

Aktivitas 3

5. Berdasarkan jawaban no di atas, apakah makanan yang dikonsumsi Ayah telah memenuhi 2.500 kalori per hari, dan Ibu 2.000 kalori per hari? Berapa jumlah makanan yang mengandung karbohidrat dan protein yang seharusnya mereka konsumsi dalam sehari? Berikan alasan!

ayah = karbo = $160 \times 4 = 640$
prote = $340 \times 4 = 1360$
2000 kalori

ibu = karbo = $120 \times 4 = 480$
prote = $680 \times 4 = 2720$
3200 kalori

Jadi, kalori yang dikonsumsi ayah kurang 500.
Sedangkan kalori yg dikonsumsi ibu lebih 1.000.
mereka belum memenuhi gizi yg seimbang, karbohidrat yang
dimiliki ayah kurang sedangkan gizi yang dimiliki ibu berlebihan.

Figure 26. student 5's answers to activity 3

6. Perhatikan kembali pertanyaan yang ada pada permasalahan, namailah Yaerlin dan Yonatan untuk menjawab permasalahan tersebut!

a. ayah = karbo = 640
prote = 1360 = 2000

ibu = karbo = 480
prote = 2720 = 3200

b. laki-laki = $\frac{2500}{2} = 1250$
= karbo = 400
= prote = 1200

Perempuan = $\frac{2000}{2} = 1000$
= karbo = 300
= prote = 700
makan = 1.200

c. untuk mencegah malnutrisi pada makan yg seimbang dan teratur.
3. Sumber zat tenaga (karbohidrat) dan
Sumber zat Pembangun (Protein).

Figure 27. student 6's answers to activity 3

In activity 3 no 5 that checks the answers, students are herded through questions that are reminiscent of the problems contained in the news, namely the number of calories they have consumed.

In activity 3 no 6 above, students are led to find solutions to problems that occur in the news. Namely by giving questions on how to prevent malnutrition that occurs in Indonesia, and how much food should be consumed by Father and Mother to meet calorie needs every day.

3.1.3 Teaching experiment results

Malnutrition in Indonesia

Intan Zahar is one of the children suffering from acute malnutrition. The head of administration and public relations at the North Aceh Regency hospital, Saiful, on Thursday (2/24/2019) said that since a week after being treated at the hospital, the condition of Intan Zahar continues to improve. Her weight has increased by 2.5 kg. The appetite for food is good. Already want to eat, drink milk, and bread. (Kompas.com) 1 gram of protein equals 4 calories; one gram of carbohydrate equals 4 calories. (hallosehat.com)

Weight of one type of food containing carbohydrates and 1 type of food containing protein is 100 grams. While the weight of one type of food containing carbohydrates and two types of food containing protein is 140 grams. How many grams of carbohydrates and protein does Intan Zahar consume?

Figure 28. Problem in Teaching experiment

In activity 1 of the second meeting, it appears that students are more fluent in working on problems number 1 to number 2. The following answers students on the problem of activity 1.

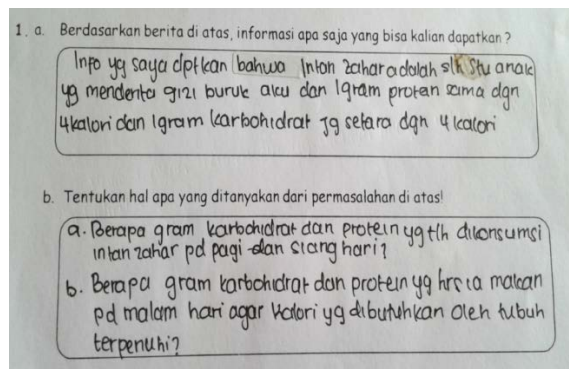


Figure 29. student 1's answers to activity 1

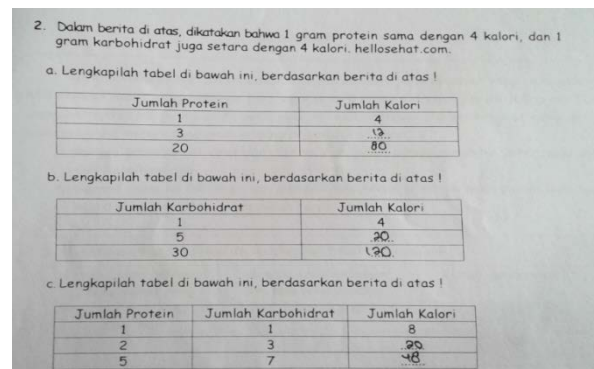


Figure 30. student 2's answers to activity 1

In number 1 above, namely understanding the problem, it appears students easily answer each question, when compared with the first meeting students look more smoothly in answering activity 1 no 1.

In number 2 above, which is to make the foundation of thinking, students also look more fluent in filling tables, because they have worked on Activity 1 at a previous meeting, which is almost the same way of doing it.

In activity 2, which is to make a mathematical solution, students fill in the table of the amount of food consumed by Intan Zahar in the morning and afternoon and determine the symbols and make them into mathematical form. Students also determine the coefficients, variables and constants of the mathematical form they have made, make a mathematical solution and determine the mathematical results. The following are the students' answers to Activity 2.

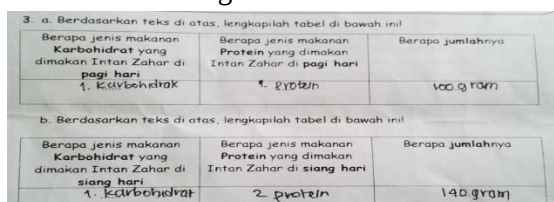


Figure 31. student 3's answers to part a and b activity 2

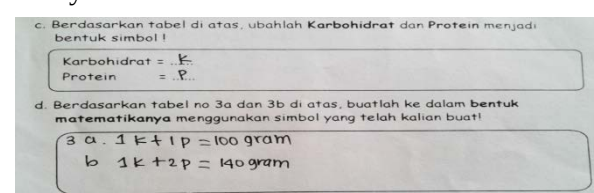


Figure 32. student 3's answers to part c and d activity 2

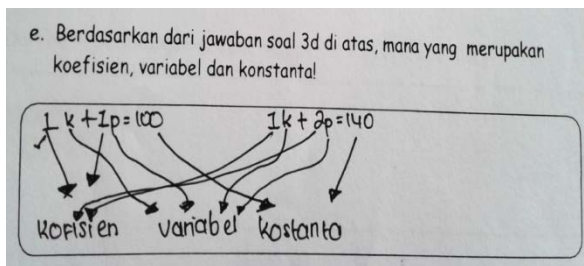


Figure 33. student 3's answers to part e activity 2

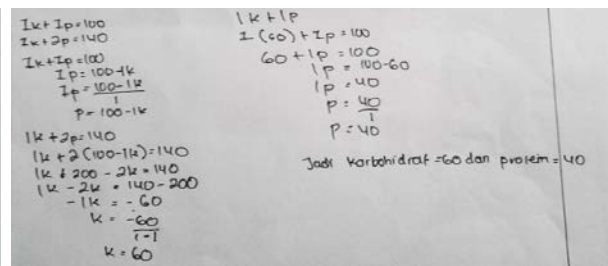


Figure 34. student 4's answers to part a activity 2

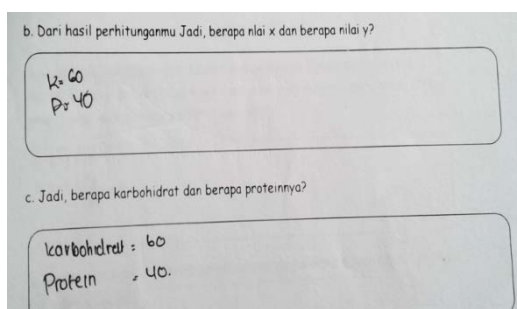


Figure 35. student 4's answers to part b and c activity 2

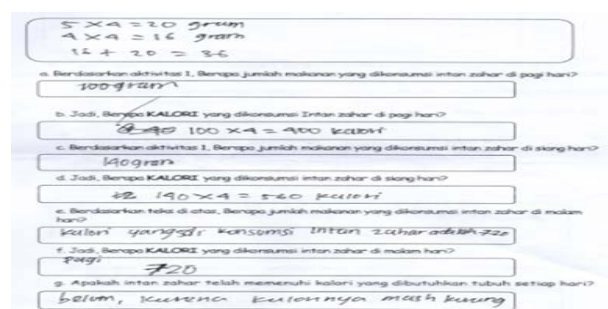


Figure 36. student 5's answers to activity 3

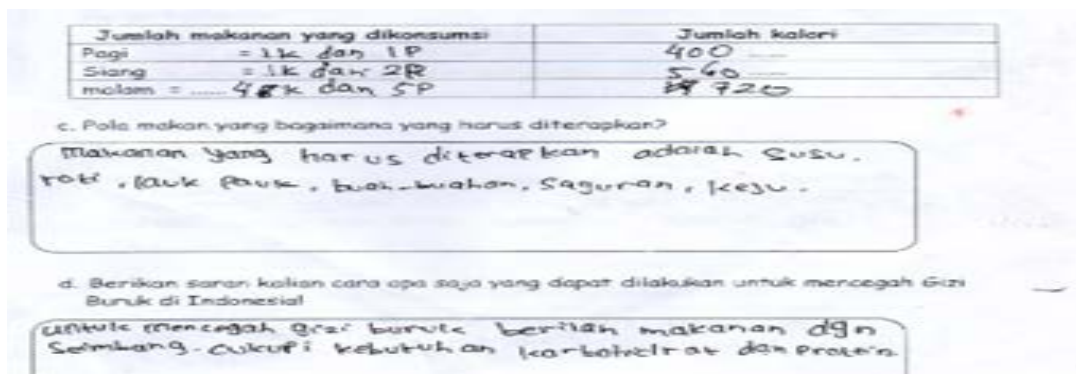


Figure 37. student 6's answers to activity 3

In activity 2 above, it appears that students are more fluent in working on activity 2 no 3, without giving direction students already know what the intentions and answers to the activity 2 are. From the students' answers above, it appears that the students' answers are directed and there are no difficulties or confusion. From activity 2 number 3 and number 4 the students can answer correctly.

In activity 3, students are expected to be able to interpret and report the results they have obtained. Here students are asked to fill in how much food and calories are eaten by Intan Zahar in the morning, afternoon and evening. Then students match the results of their answers to the real problem questions, namely whether Intan Zahar has met the calorie needs on that day, as well as what diet can be done so as not to experience malnutrition and give their advice to Intan Zahar and children in Indonesia. Following are the answers of students in activity 3.

4. Conclusion

The health context can be used in a two-variable linear equation system, using real-world context students are guided to be able to identify problems, make assumptions, make mathematical models, analyze answers, interpret and carry out modeling, so that when students are given questions that require analysis or problem solving, they can solve problems. The role of learning activities in supporting students' mathematical modeling skills in the material system of two-variable linear equations is as follows: a) in activity 1, students can understand and identify problems by watching videos and reading news on student worksheets. Students can calculate the weight of carbohydrates eaten that produce calories, the protein eaten that produces calories and the amount of carbohydrate weight plus the weight of protein eaten, which produces calories. b). in activity 2, students can make mathematical forms and make solutions / solutions in mathematical form with mathematical calculations in a two-variable linear equation system using the substitution method. c). in activity 3, students can interpret mathematical answers to real world problems, then students can present problems in the form of real solutions based on mathematical solutions in the calculations they get.

Acknowledgments

I thank Mr. Dr. Darmawijoyo, M.Si., M.Sc., and Mother. Dr. Ely Susanti, M.Pd. as a guide. In making this article, has given many suggestions and inspiration. Thanks also to the students of SMP N 21 Palembang, who have contributed in conducting experiments in the learning process with mathematical modeling using the MEAs approach in the health context of malnutrition in Indonesia.

References

- [1] Akker J V D, *et al* 2006 *Educational Design Research* (New York: Routledge Taylor & Francis Group)
- [2] Dorman L I 1975 *Variations of Galactic Cosmic Rays* (Moscow: Moscow State University Press)
- [3] Ang K C 2009 Mathematical modeling and real life problem solving *Mathematical Problem Solving Yearbook 2009* (Singapore: World Scientific)
- [4] Bakker A 2004 *Design Research In Statistics Education: On Symbolizing and Computer Tools* (Utrecht: Frudenthal Institute)
- [5] Bliss K and Libertini J 2016 *Guidelines for assessment & instruction in mathematical modeling education (GAIMME) chapter 1, United States of America*
- [6] Blum W 2009 Mathematical modelling: Can it be taught and learnt? *Journal of Mathematical Modelling and Application* 2009 **1** 45-58
- [7] Blum W 2015 Quality teaching of mathematical modeling: What do we know, what can we do ? *The Proceedings of the 12th International Congress on Mathematical Education* 73-95
- [8] Brown J 2015 Editorial: What is mathematical modelling? *Journal of Australian Senior Mathematics Journal Volume* **31**
- [9] Chamberlin S A and Moon S M 2008 How does the Problem Based Learning Approach Compare to the Model-Eliciting Activity Approach in Mathematics *International Journal for Mathematics Teaching and Learning* **9** 78-105
- [10] Cirillo M, *et al* 2016 Perspectives on modeling in school mathematics *The National Council of Teachers of Mathematics* 3-16
- [11] Edwards D and Hamson M 2007 *Guide to Mathematical Modeling* (New York: Industrial Press, Inc.)
- [12] Fauziah, Darmawijoyo and N Aisyah 2017 *Pengaruh Pendekatan Pemodelan Matematika terhadap Kemampuan Pemecahan Masalah Siswa pada Materi Sistem Persamaan Linier di Kelas X SMA Muhammadiyah 2 Palembang* Thesis
- [13] Gravemeijer K 1994 Educational development and developmental research in mathematics education *Journal for Research in Mathematics Education* **25** 443-71
- [14] Khuluq M H, Zulkardi Z and Darmawijoyo D 2015 Enhancing Students 'Strategis to Solve Linear Equations With One Variable Through Balancing Activities *Proceeding The 3rd South-East Asia Design/Developmental Research (SEA-DR)* 156-65

- [15] Kurniawan A H 2007 *Analisis Kesalahan Siswa dalam Menyelesaikan Soal Cerita Pokok Bahasan Sistem Persamaan Linier Dua Variabel pada Siswa Kelas VIII Semester Ganjil SMP Negeri 6 Sukoharjo Tahun Ajaran 2006/2007* Thesis
- [16] Lowe J, Carter M and Cooper T 2018 Mathematical Modeling in the junior secondary years: An approach incorporating mathematical technology *Journal of Australian Mathematics Teacher* **74** 4-12
- [17] Lutfianto M, Zulkardi and Hartono Y 2013 Unfinished student answer in PISA mathematical contextual problems *Journal on Mathematics Education (IndoMS-JME)* **4** 201-8
- [18] OECD 2013 *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy* (Paris: OECD Publishing)
- [19] Ortner J 2010 *Fundamentals of Math book 2 Algebra 1* (Bloomington: AuthorHouse)
- [20] Pollak H 2003 The interaction between mathematics and other school subjects *New Trends in Mathematics Teaching IVP* 232-48
- [21] Selvia F R, Darmawijoyo and Yusuf M 2014 Penerapan pembelajaran pemodelan matematika menggunakan pendekatan konstruktivisme terhadap kemampuan pemecahan masalah untuk siswa kelas VIII SMP *Jurnal Pendidikan Matematika* **3** 66-74
- [22] Simon M A 1995 Reconstructing mathematics pedagogy from a constructivist perspective *Journal for Research in Mathematics Education* **26** 114-45
- [23] Susanti A O, Hartono Y and Darmawijoyo D 2016 Desain pembelajaran pemodelan materi Sistem Persamaan Linier Dua Variabel di Sekolah Menengah Pertama *SEMIRATA Bidang MIPA 2016, BKS-PTN Barat*
- [24] Turmudi, *et al* 2014 Pengembangan Pembelajaran matematika dengan Pemodelan (Mathematical Modeling) berbasis realistik untuk mahasiswa *Jurnal Pengajaran MIPA* **19** 1-18
- [25] Van De Walle J A 2007 *The sixth edition of Primary and Secondary School* (Jakarta: Erlangga)
- [26] Van den Akker J, Gravemeijer K, McKenney S and Nieveen N 2006 *Educational Design Research* (London and New York: Routledge)
- [27] Wijaya A A and Marsiyah M 2013 Analisis kesalahan siswa dalam menyelesaikan soal cerita materi Sistem Persamaan Linier Dua Variabel *MATHEdunesa* **2**
- [28] Wulandari W, Darmawijoyo and Hartono Y 2016 Pengaruh pendekatan pemodelan matematika terhadap kemampuan argumentasi siswa kelas VIII SMP Negeri 15 Palembang *Jurnal Pendidikan Matematika* **10** 111-23