Developing Students Understanding of Mathematical Model on System of Linear Equation With Two Variables

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Abstract

Students are difficult to make mathematical model for solving algebraic word problem especially in system of linear equation with two variables. For simple problems, students can be directly make the mathematical model. They just translated from word to symbol or variable. For complicated problem like problem about difference of two things, students usually confuse to interpret phrase by phrase. Because of that students make errors in making equation. Therefore, we designed a meaningful learning which can give students a chance to construct their comprehension about mathematical model. This paper is part of a Master Program Research which aims to find the solving of system of linear equations with two variables. But, this paper will focus only on learning design to develop students understanding of mathematical model on system of linear equation with two variables. Design research was used as research approach of this study and scientific approach is a cornerstone in designing learning activity. In this learning design, students gave various problems and asked them to make the mathematical model. From students error in making mathematical model, students can improve their ability about how to make the right mathematical model on system of linear equations with two variables.

Keywords: Mathematical model, System of linear equation with two variables

INTRODUCTION

Understanding a problem includes two process: Representing patterns of information in the meanings of terms in the text and constructing a conceptual model that represents the situation in the text namely mathematical model (Jonassen, 2003). MacGregor&Stacey (1993;1998) noted that students often have difficulties in formulating algebraic equation for word problems even simple linear equations with two variables. Cummins et al in Koedinger & Nathan (2004) also indicates that students have difficulties in comprehending specific linguistic form such as some, more Xs than Ys, and together.

Hegarty, Mayer and Monk (1995) said that students usually do direct translation to solve word prolems by using the keyword method and number grabbing. In the keyword method, the problem solver attempts to select the numbers in the problem and key relational terms (such as “more” and “les”) and develops a solution plan that involves combining the numbers in the problem using the arithmetic operations that are formed by keywords (e.g., addition if the keyword is “more” and subtraction if it is”less”). In number grabbing method, the students just do a set computation without consideration the situation described in the problem.

We must concern about students error in making mathematical model. If they cannot make the right mathematical model, they cannot answer system of linear equations with two variables by using algebraic method (see MacGregor dan Stacey, 1998). In this study we designed meaningful learning that give a chance for students to construct their comprehension about mathematical model on system of linear equations with two variables. We hypothesized that by giving various problems for students and asked them to make the mathematical model in the beginning, they can learn how to make the right one from their mistake.

The learning activity was designed and investigated according to a design research approach. Design research is a type of research that allows researchers to develop instructional activities and analyze the actual process of students' learning and mental activities when they participate in the instructional activities. Scientific approach as approach which suggested by government in curriculum 2013 is a cornerstone in designing learning activity. The research question is: how can learning design by using scientific approach help students to construct their comprehension about mathematical model on system of linear equations with two variables. This paper is part of a Master Program Research which aims to find the solving of system of linear equations with two variables.

THEORETICAL FRAMEWORK

Mathematical Model

Word problem can be solved by using the following ways (Macgregor and Stacey, 1998):

a. Propositional text base, the answer to the problem is obtained by guess and check.
b. Situation models, a cognitive model of problems description. Students can use arithmetic calculation by giving a logical reason.
c. Problem models, is an important step in solving algebra problems. The information presented is no longer presented in verbal form but students should make an equation using variables.

The formal way to solve word problem is problem models. The term models refers to purposeful mathematical descriptions of situations (Lesh & Lehrer, 2003). The same opinion from English, Fox, & Watters (2005) that models are used to interpret real-world situations in a mathematical descriptions. For example, graphs, tables and equations are used to model of relationships among various phenomena (Kang & Noh, 2012). From the following opinions, mathematical models are used to describe situation. In making mathematical model for word problem, problem solvers also requires construction of generic proposition, such as quantity (number, some, how many), possession (have, give), compare (more than, less than), and time (past, beginning, then) (Jonassen, 2003). By consideration of the keywords, problem solver can make the right mathematical model.

Scientific Approach

In curriculum 2013, government recomended to use scientific approach in learning design which phases are (Kemdikbud, 2013):

a. Observing
   Observing activities can be reading, listening,and scrutinizing. Observing mathematical objects can be grouped into two kinds of activities, namely:

1) Observing the phenomenon in everyday life associated with certain mathematical objects.
2) Observing that abstract mathematical objects.

b. Questioning
Questioning activity may constitute the submission of the question by students about information that is not understood from what is observed or question to get additional information about what is observed.

c. Collecting Information / Experiment
Learning activities in order to collect information / experiments can be:
1) Conduct experiments
2) Reading sources other than textbooks
3) Observe the object / event / activity
4) Interviews with speakers

d. Associating / Processing Information
Learning activities in this step isprocessing the information from collecting information activities / experiments , observing and questioning.

e. Communicating
Learning activities in the last step is conveying the results of observations, conclusions based on the results of the analysis of oral, written, or other media.

METHOD

This paper is a part of design research project on learning design of topic system of linear equations with two variables (Husna, 2014). This study has three phase (Gravemeijer and Cobb in Akker, 2006):

a. Preparing for the Experiment
At this phase the researchers conducted several activities including reviewing the literature, examined the condition of the student and design Hypothetical Learning Trajectory (HLT). Reviewing literature covers the curriculum, scientific approach, and the concept of mathematical model on systems of linear equations with two variables. To investigate the conditions of students researchers conducted interviews with teachers and students and observation. Results of interviews and observations are used as a material consideration when researchers want to design the learning activities of students in order to more appropriate design. HLT which designed by researcher consists of learning objectives, plan instructional activities, conjecture/hypothesis of the learning process so that teachers can anticipate how development of students' understanding of mathematics (Simon, 1995).

b. Teaching experiment
In a design research, the teaching experiment consists of preliminary teaching Experiment (first cycle) and teaching experiment (second cycle). Learning in the first cycle test the initial HLT which has been designed. The first cycle aims to collect the data, adjust and revise (if necessary) HLT. Students are involved in this cycle consists of low, medium and high ability. Learning in the second cycle which is the core phase of a design research. At this phase the new HLT which is a revision of the initial HLT, tested in actual class. Mathematics teacher acted as the teacher while the researchers observe student's learning activities.

c. Retrospective Analysis
Data obtained from the learning activities during the teaching experiment were analyzed and the results are used as consideration for the next learning activity. At this phase, the HLT compared to students' actual learning. Feedback from teachers provide useful information for the researchers to get a better learning design. Thus, HLT is a guideline in a retrospective analysis to investigate the learning of students in discovering the process of replacing, eliminating and combination.

The participants of this study are the students of 8thgrade Junior High School 17 in Palembang. Six students in grade VIII.4 are involved in the first cycle and 41 students in grade VIII.5 participated in the second cycle. All the videos of the learning activities in the class, field notes, and the students' works were collected as the data collection. This paper discuss activity of making mathematical model in cycle 2.

RESULT AND DISCUSSION

Learning activity started by giving various problems for students and asked them to observe it. Teacher and students did question and answer activity about mathematical model. Some students have to understand that mathematical model related to use variables in the form of letters connected by arithmetic operation signs. Thus the class discussion about the mathematical model can be run quickly. Next, students discussed in group to create mathematical models of the problem which given and they have freedom to use whatever variables.

The first problem can be completed by most students correctly. Only two of ten groups gave wrong answers because they did not consistent on using variables for same objects in a problems as shown in Figure 1. This could happen because the students did not understand very well about using variables in mathematical models. Students assume that every object in the problem can be replaced with the letter without consideration to rules of consistency for same type.

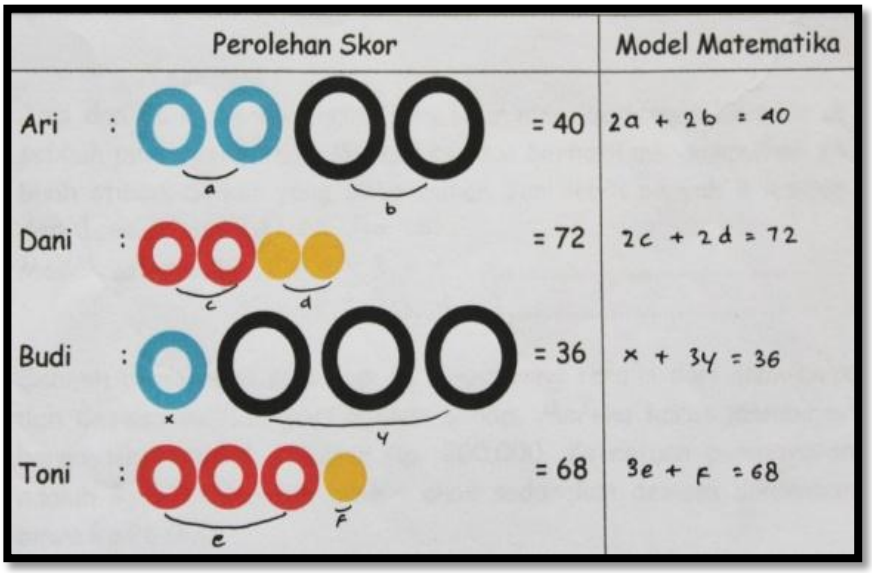
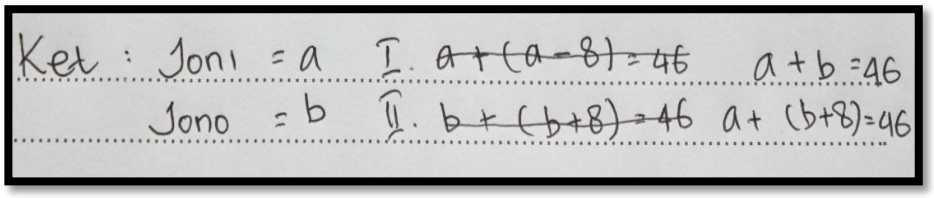


Figure 1. Student's error in using variables

Students begin encountering obstacles in making mathematical model for a more complicated word problem. The second problem about obtaining stickers by Joni and

Jono. The some of both stickers are 46 and joni's sticker is 8 more than jono's sticker. Many students made the mathematical model of this problem incorrectly. Students mistake can be seen from the following figure 2.



(a)

(b)

Figure 2. Student's error ini answer the second problem

In Figure 2 (a) shows that the students are not confident in answering the problem given. Students have to understand that there are two mathematical models for that problem, but they wrong in interpreting it. Both answers were crossed by students is the right thing where students replaced b with a - 8 and a with b + 8. These students eventually changed his mind and replace the mathematical models that have been written. The first equation is true that the student wrote the sum of stickers is 64. Students wrote the second equation mistakenly in which the variable b replacing with b + 8. In this case it is known that these students have to understand the mathematical model for word problems. However, students are still in doubt on the meaning of making two mathematical models for the given problem.

In figure 4.2 (b) shows that the students made the first mathematical model correctly. Students error is on mathematical model for the description of the word "more". Students were wrong in interpret who has more number of stickers. The correct mathematical model for this problem is x = 8 + y.

Other mistakes found in the second problem are the students not working in accordance with the instructions to makethe mathematical model. Students perform arithmetic operations for each number that appears on the problem without consideration to the description. In addition it was also found that students just make an equation that is x + y = 46.

The third problem about 12 visitors on a circus show with the price of the entrance tickets is Rp. 200,000. Terms of payment are Rp. 10,000 for childrenwhile an adult charged Rp. 20,000. Several groups understood that 12 visitorsare consist of adults and children is the first equation. However, students confused to make the next mathematical model. Here's an excerpt of dialogue between a group and researcher about mathematical model for this problem.

: You wrote the right first equationthat a + b = 12.
Researcher How about the second equation?
(The first group was confuse)

Researcher : Now let we pay attention to the next sentence in this problem.
(The first group pay attention to the third problem)
Researcher : What is the next explanation?
Student 1 : The total ticket price to be paid is Rp. 200.000 with requirement for adult is Rp. 20.000 and child is Rp. 10.000
Student 2 : It's mean the number of adult are 8 and children are 6
Researcher : We are not discussthe solution now.
This students worksheet just command to make the mathematical model.
Student 1 : The meaning is Rp. 200.000 for all visitors that consist of children and adult tickets.
Researcher : So what is the mathematical model?
Student 1 : 200.000=10.000+20.000
Researcher : So what else is lacking in the mathematical model?
Student 1 : 200.000=10.000a + 20.000b
Researcher : Yes that's right. Please make it in the worksheet

After all groups have completed the students worksheet, learning activities followed by presentation of some groups forsame perception of the mathematical model. Problem number 1 was not presented because the majority of the group has been answered correctly. Students focus to discuss the numbers 2 and 3because these problems are difficult for students.

Learning activities followed by a class discussion that led by the teacher about things that were important in making a mathematical model. The teacher also asked students to explain what is the meaning of linear equations with two variables and systems of linear equations with two variables.

Based on the implementation of this learning design, it is known that there are students who does not understand the consistency in the use of variables in a problem. Thus the assertion needto be given for students that the same object in a problem using the same variables and it is in general use adjacent letters such as a and b, x and y, and so on.
Students have difficulty in making mathematical models for complex problems as problems of numbers two and three. The dominant problem of students are in interpreting information about the difference of thing (eg. More than and less than).In addition, the students tend to perform arithmetic operations on the numbers that appear in the problemwithout consideration the meaning, if they do not know the mathematical models. Therefore, students need more practice to create a mathematical model in order to minimize the errors as described above.

CONCLUSION

The result of this study shows that by giving problems for students in the begining of lesson and ask them to make the mathematical model can explore their ability. Some students make the wrong mathematical model, so we can identify their error. From the students error, they can contruct their comprehension about how to make the right mathematical model. Giving meaningful learning for students by using step of scientific

approach will not only help students to develop their comprehension about the topic but also can improve their social acitivities like doing discussion, giving opinion or argumentation and etc.

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