Supporting second grade lower secondary school students’ understanding of linear equation system in two variables using ethnomathematics

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Abstract. The aim of this research is to know the students’ understanding of linear equation system in two variables using Ethnomathematics and to acquire learning trajectory of linear equation system in two variables for the second grade of lower secondary school students. This research used methodology of design research that consists of three phases, there are preliminary design, teaching experiment, and retrospective analysis. Subject of this study is 28 second grade students of Sekolah Menengah Pertama (SMP) 37 Semarang. The result of this research shows that the students’ understanding in linear equation system in two variables can be stimulated by using Ethnomathematics in selling buying tradition in Peterongan traditional market in Central Java as a context. All of strategies and model that was applied by students and also their result discussion shows how construction and contribution of students can help them to understand concept of linear equation system in two variables. All the activities that were done by students produce learning trajectory to gain the goal of learning. Each steps of learning trajectory of students have an important role in understanding the concept from informal to the formal level. Learning trajectory using Ethnomathematics that is produced consist of watching video of selling buying activity in Peterongan traditional market to construct linear equation in two variables, determine the solution of linear equation in two variables, construct model of linear equation system in two variables from contextual problem, and solving a contextual problem related to linear equation system in two variables.

1. Introduction

Algebra is an important part of school mathematics but is challenging for students to learn [1-3]. There are several studies indicate that students of all grade levels have problems working with variables [4-6]. In line with this, the main difficulties in algebra for many secondary school students all over the world is solving word problems [7-10]. For instance, students still get difficulties in mathematizing from the reality situation. This problem can lead the students to get difficulties in solving the world problem.

Furthermore, according to Khuluq [11] reasons due to the difficulties encountered by the students address two issues, that is, the content of the algebra itself which is different from (arithmetic) mathematics that students usually dealt with, and inability of teachers to present good algebra learning due to the absence of a guidance they could adapt in their teaching. In line with this, many teachers teach algebra, yet the preparation of algebra teachers has not been widely researched [12].
Moreover, based on the background stated, designing of teaching material using appropriate approach and a good context should be needed in order to help students’ understanding the algebra concept, especially in linear equation system in two variables that is taught in the second grade of lower secondary school students. One of appropriate approach that can be used is realistic mathematics education (RME) enriched by ethnomathematics using local wisdom as a context. Based on several studies about the use of RME or in Indonesia it is called as PMRI give results that the use of appropriate context for learning give a positive influence on learning mathematics that more meaningful, fun, and it can improve students’ understanding of mathematical concepts learned [13]. This is in agreement with the Hans Freudenthal’s views of RME, namely: “mathematics must be connected to reality, and mathematics as human activity” [14]. In line with this, mathematics is not just transferred by the teacher to the student, but it is actively engaged in by students to reinvent the mathematical concepts in their own way [15]. This is confirmed also by Baba [16] that, when we regard children’s activity as acting upon their own environment, the environment should include not only mathematical objects but also other objects, which are highly related to their own culture, that we call it as ethnomathematics.

In addition, there two research questions which are how do the students’ understanding of linear equation system in two variables through Hypothetical Learning Trajectory (HLT) designed and how do the Learning Trajectory of linear equation system in two variables using Ethnomathematics developed from informal to formal mathematics level? Hopefully, this effort can help students understand linear equation system in two variables concept through HLT provided and describe that HLT designed.

2. Methods
The methodology used in this study is design research using Ethnomathematics. The aim of design research is to formulate a Hypothetical Learning Trajectory (HLT), which can be elaborated and refined during the research process. There are several steps undertaken in this study, namely: preliminary design, teaching experiment, and retrospective analysis. In this study, there is a learning path on the topic of linear equation system in two variables as a series of students’ activities consist of conjecture and thinking strategies that can be changed and evolved during the teaching experiment. So that the implementation of the design research consists of some stages which is a cyclical process of thought experiments and instruction experiment [15]. The data that was collected in this study were written and audio-video data. The subjects in this research were the second grade students of lower secondary school (SMPN) 37 Semarang.

3. Result and Discussion
Based on the research that has been conducted, it can be obtained that students’ understanding of the concept of linear equation system in two variables can be supported from several activities, namely watching learning movie to construct linear equation, determine the solution, construct model of linear equation in two variables from contextual problem, and solving a contextual problem using some methods. As well as students’ learning trajectories can be generated from informal level to formal level. Furthermore, results and discussion of it can be described as follows.

3.1. The students’ understanding of the concept of linear equation system in two variables
Students' understanding of the concept of linear equation system in two variables using ethnomathematics and also the learning trajectory that was produced could be described as follows.

3.1.1. Students can construct linear equation in two variables by watching learning movie
Students watched learning movie about selling buying tradition happened in the Javanese traditional market. From this activity, students can identify the contextual problem that related to linear equation in two variables. After watching that learning movie, students were guided by the teacher to construct
the linear equation in two variables. In addition, students’ activity in watching movie can be seen at the Figure 1.

![Figure 1. Students watched learning movie](image1)

In this phase, the teacher remind first about linear equation in one variables that have learned by the students in the first grade. After reminding the students, then the teacher guided them to construct linear equation by mathematizing the word problem into variables, such as x and y.

Furthermore, teachers can explore the results of watching learning video activity about selling buying tradition in the traditional market in Central Java to guide students to reinvent concepts of modelling the contextual problem into mathematics form, such as linear equation in two variables.

3.1.2. **Students can determine the solution of linear equation in two variables**

In the second activity, students were guided to determine the solution of linear equation in two variables through some steps. Firstly, they find the price of each vegetables and its multiplication. Secondly, they were guided to completing table of combination price between two kinds of vegetable that meet the given linear equation. Next, they could find the various appropriate combination price that fulfill the linear equation in two variables. Furthermore, the students ability in doing those steps can be seen at picture 2.

![Figure 2. Students work in determining the solution of linear equation](image2)

Based on the Figure 2, it can be clearly seen that the students ability in determine the solution of linear equation system can be guided by some tasks provided in the students’ worksheet. Students could find the series of price, then found the appropriate combination price, and make a list of any combination price into linear equation in two variables, in that case the student could write five alternative linear equation in two variables. From this activity, the understanding of the students in the concept of linear equation system in two variables can be constructed by trying to find the alternative solution that meet the equation.
3.1.3. **Students can construct model of linear equation system in two variables from contextual problem**

Students could construct linear equation in two variables through solving given problem on the students worksheet with their group. In this activity, students stimulate by some contextual problems using ethnomathematics, namely selling buying tradition at traditional market that have been watching by them. One problem is that Zahin need Rp 35,000.00 to buy 2 packs of corn and 4 packs of cassava, while another problem is Azkia need Rp 52,000.00 to buy 4 packs of corn and 5 packs of cassava. Then, construct the mathematical form from that problem.

After giving that problem, students discussed it with their group and presented it in front of the class. Furthermore, the students answer about that problem can be seen at picture 3.

![Figure 3. Student work in completing table form the linear equation](image)

Figure 3 shows students work in students worksheet. It can be clearly seen that the students could construct the mathematical form as linear equation in two variables such as j and s as representatif of corn and cassava respectively. After construct the linear equation in j and s variables, then they try to find the value of j and s as the price of corn and cassava by completing the table. They can find the appropriate value for the blank cells so that the value can meet the linear equation correctly. In addition, by comparing value of j and s from both linear equations, then they could find the same value of j and s. Furthermore, that same value can be concluded as a solution of linear equation system in two variables. They could find the appropriate value of j and s fulfilled both linear equations was 5.500 and 6.000 respectively, especially for that given problem.

3.2. **Students can solve a contextual problem related to linear equation system in two variables**

In this activities, students can solve contextual problem related to linear equation system in two variables using various methods, namely substitution, elimination, graph, and mixed method. In addition, one of example of students work from the students worksheet can be seen at Figure 4.

![Figure 4. Students’ work from given problem](image)

Based on the Figure 4, it can be seen that the students could understand the concept of linear equation system in two variables then they could apply it to solve the contextual problems related to that material. Through solving some problems in students’ worksheet with their group, the students
could show the enthusiastic in communicating their idea in solving the given problem. After discussing those problems, and try to solve it, they could construct their ability to solve problems in daily life. Furthermore, the form of ask answer between teacher and students shows that students were able to solve contextual problem related to linear equation system in two variables as follows.

Teacher : "Ok class, after discussing the problem on your worksheet, can you solve those problems there?"

Students : “Yes Mom”
Teacher : “How much the price of one cabbage and spinach?”
Shidiq : “The price of cabbage is Rp 3.000,00 and spinach is Rp 5.000,00”
Teacher : “Ok, good! How do you get it?”
Shidiq : “Using some methods, substitution, elimination, graph, and mixed method”
Teacher : “How about the result? Are all the same result?”
Shidiq : “Yes, all methods have the same result”
Teacher : “Which one is the easiest methods?”
Shidiq : “Hmm... mixed method I think”
Teacher : “Why?”
Shidiq : “Because I could find the result quickly and simpler”
Teacher : “Ok, good. Please write down your answer on the white board”.

From the ask answer activity between teacher and students, the students presented the results of their discussion in front of the class and the other gave respond by guidance from the teacher. The teacher lead to the discussion in the class by asking other students, whether there was different result or no. If there was different result, they should communicate it in front of the class. Students were excited in presenting their idea to the class, because they felt free to communicate their opinion and asking question about material that remain difficult for them.

After carrying out activities designed and group discussions in solving some problems in the student worksheet, it could be known that students could understand the concept learned and apply it to solve given contextual problems. Therefore, this activity could support the students' understanding of the concept of linear equation system in two variables and their problem solving ability.

3.3. Learning trajectory of linear equation system in two variables

It can be produced learning trajectory based on some activities done by the students that is expected to be applied in developing learning instructional theory of linear equation system in two variables. Furthermore, this learning trajectory using Ethnomathematics can develop students' understanding concept of linear equation system in two variables from informal level to formal level. Then, learning trajectory of linear equation system in two variables can be seen at Figure 5.

Figure 5. Learning trajectory of linear equation system in two variables using ethnomathematics
Based on the picture 5, it can be clearly seen that the learning trajectory of linear equation system in two variables consist of four activities designed starting from the use of contextual problem to formal mathematics level. The first activity is watching learning video about selling buying tradition in traditional market to make linear equation in two variables. The second activity is determining the solution of linear equation in two variables. Next, constructing model of problem from linear equation system in two variables. The last is solving a contextual problem related to linear equation system in two variables.

4. Conclusion
The students’ understanding of linear equation system in two variables can be supported by ethnomathematics. The students’ understanding can be developed from informal to the formal level. Students can reinvent concept of linear equation system in two variables from their experience in some activities enriched by ethnomathematics. Learning linear equation system in two variables by using ethnomathematics and selling buying tradition in traditional market as a context and PMRI approach can stimulate students’ understanding about topic concept learned, and they can use their understanding that concept to solve contextual problem related to linear equation system in two variables.

Furthermore, learning trajectory resulted to support students thinking strategy as a model consist of four activities which are watching video of selling buying activity in Peteronongan traditional market to make linear equation in two variables, determining the solution of linear equation in two variables, constructing model of problem from linear equation system in two variables, and solving a problem related to that material.

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