Assessing the Effect of an Ethnomathematics Teaching Material on Students' Understanding of Mathematics

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Abstract: The integration of cultural context in mathematics teaching materials is a form of implementing ethnomathematics-based teaching. It is an effort of making mathematics learning easier and meaningful. This paper reports the effect of an ethnomathematics teaching material on students' understanding of linear equations at the Department of Primary Education Universitas Syiah Kuala. 105 students participated in the study. Students' understanding was assessed using a test. Data analysis was conducted using descriptive qualitative method. Students' understanding of linear equation was analyzed based on 3 aspects of solving linear equation problems: correctly translate word problems into linear equation, perform calculation correctly, and give correct final answer. Results showed that more than 83% of the students could answer the test satisfactorily. Therefore, it is concluded that the implementation of the ethnomathematics teaching material helps students understand linear equation. This finding implies that the implementation of ethnomathematics teaching material is beneficial for mathematics learning.

Keywords: assessment, ethnomathematics, linear equation

Mathematics is a subject that is often considered difficult by students at school and university levels. In fact, previous studies reported that students dislike mathematics (Az-Zahroh et al., 2019; Gafoor & Kurukkan, 2015) and have anxieties in learning mathematics (Yanuarto, 2016). There are many reasons why students find learning mathematics difficult, such as difficulties in understanding math terms and concepts, and lack of real-life-related examples in teachers' explanation (Mulwa, 2015). Education practitioners around the world have been attempting to investigate students' difficulties and find easier ways to teach mathematics to students.

Understanding mathematics concepts are crucial for students, especially for pre-service teachers. This is because in order to teach mathematics well, a teacher must have solid understanding of the concepts. The teaching of mathematics at the Department of Primary Education at Universitas Syiah Kuala in Banda Aceh is aimed at preparing pre-service teachers to have deep understanding of mathematics. Among mathematics concepts taught at the Department is linear equation. It is essentially the skill to translate real-life problems into mathematical equations and then solve them using mathematical procedures. It is an important skill to be acquired because it is related to real-life application and it is a pre-requisite to understand more advanced subjects such as quadratic equations. Unfortunately, students' scores over the years show that their understanding of linear equation is poor. Formative evaluation over the years show that students are struggling in understanding word problems, identifying information presented in the problems, and conducting necessary mathematical operations to solve the problems. This condition indicates the importance of better teaching strategy to help students understand linear equations.

Previous studies show that students' difficulties in learning linear equations are caused by several factors such as misconceptions of mathematical symbols and teachers' use of unfamiliar contexts which may result in meaningless learning experience (Adu et al., 2015; Jupri et al., 2014). These problems emphasis the importance of teaching linear equations in familiar contexts so that students can see the importance of linear equation and apply their knowledge in real life situations. This is as Koca (2016) suggests that when students can appreciate of the importance of a subject in real life, they will be motivated to learn it. When a student is motivated to learn mathematics, it is more likely that they enjoy learning and able to construct good understanding of mathematics concepts.

One way to teach linear equations in familiar context is by utilizing an ethnomathematics teaching material. Ethnomathematics is a practice that incorporates

daily life contexts into mathematics teaching and learning activities (D'Ambrosio, 2016). An ethnomathematics teaching and learning experience offers a contextual learning that brings students closer to the application of mathematics within a familiar context. A number of studies have reported the advantages of the implementation of ethnomathematics in the classroom. Rossa and Orey (2011) report that the implementation of ethnomathematics improves students' positive attitude and performances in mathematics. They report that ethnomathematics improves students' appreciation of mathematics as part of their daily experience (Rosa & Orey, 2011).

Implementing ethnomathematics in teaching mathematics in the classroom can be conducted by utilizing local or familiar contexts within mathematical word problems (Katsap & Silverman, 2016). Instead of using standard form of a mathematical problem, a teacher can present the problem in a familiar context. For example, a standard problem such as "What is 2.5% of 5 million?" can be made more meaningful to Acehnese students by presenting it in a word problem using a familiar context such as "The amount of zakat donation is 2.5% of someone's disposable income. If your disposable income is 5 million, how much should you pay?". This way, the students can see clearly that learning mathematics is important and meaningful. Furthermore, the implementation of ethnomathematics in mathematics classrooms help improve students' critical thinking and problem-solving skills (Palinussa, 2013; Setiyadi et al., 2018).

In order to implement ethnomathematics in mathematics teaching and learning at the Department of Primary Education at Universitas Syiah Kuala, we have conducted a research to develop an ethnomathematics-based teaching material for the subject of linear equations. We believe that this research is important because it contributes to the development of teaching materials that can improve students' understanding of linear equations through the implementation of cultural contexts. The objective of the research was to develop a teaching material for linear equations that satisfies the validity, practicality and effectiveness criteria. The novelty of the study lies in the implementation of Acehness culture into the teaching material for linear equations. As far as we know, there has been no publication on the inclusion of Acehness culture into the teaching and learning of linear equations. Part of the result of the study has been published elsewhere where we report the validity and practicality of the teaching material. In this paper we report the final part of the study which is the effectiveness of the teaching material. The research question that we address in this paper is: does the teaching material help students understand linear equations.

METHOD

Research Design

As stated earlier in the previous section, this paper is part of a designed research conducted to develop an ethnomathematics-based teaching material to be used to teach the concept of linear equations. The method of the development followed Plomp's (2013) development phases: preliminary research, developing or prototyping, and assessment. Figure 1 shows the phases of the development of the teaching material.

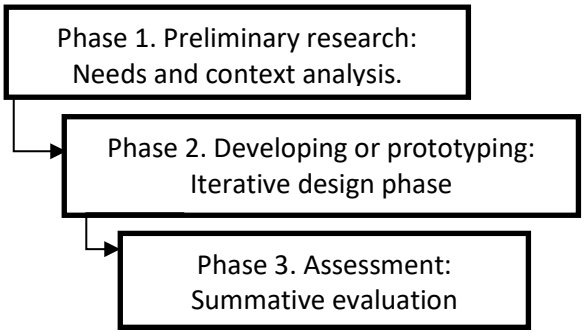

Figure 1. The Development Phases

The first phase, which is the preliminary research, is the base stage where analysis of curriculum and analysis of students were conducted; the second phase is where the prototype of the teaching material was designed and then validated; and the final phase is the assessment of the teaching materials which was done by testing the materials to target users in minor and large scales (Plomp, 2013). Phases 1, 2 and minor scale assessment phase of the research have been published elsewhere. In this paper, we report the phase of large-scale assessment.

The large-scale assessment phase was conducted by implementing the ethnomathematics teaching material at the Department of Primary Education Universitas Syiah Kuala, Aceh – Indonesia. 105 students participated in the study. 93% of the students were Acehnese. Therefore, the ethnomathematics teaching material incorporated Acehnese culture.

The students were exposed to the teaching material for 2 learning sessions on the topic of linear equation. After that, a test was used to assess the effect of the teaching material on students' understanding of linear equation.

The test consisted of 2 word-problems. In line with the teaching material, the test also used the context of Aceh culture. The validity of the instrument was analyzed based on three experts' assessment on the content, format and language of the test. The Aiken's V score for the content is 0.78; the format is 0.67; and the language is 0.67. The V score for all the aspects exceeded 0.6, therefore the test was declared valid (Azwar, 2012). For the reliability test, the instrument was tried to 25 students. Calculation of Cronbach's alpha using Microsoft Excel showed that the alpha coefficient is 0.72 which means that the instrument is reliable (Azwar, 2012).

Data analysis was conducted using descriptive qualitative method where students' understanding of linear equation was assessed based on their ability to 1) translate word problems into linear equation, 2) calculate mathematical operations, and 3) present correct final answer to the problems. The three aspects above were based on Polya's problem solving techniques which consisted of identifying of a problem, planning a solving strategy, and re-checking the final answer (Lee, 2017). Data analysis can be described as follow. First, based on the three aspects of the valuation, students' answers for questions 1 and 2 were classified into 'correct' or 'incorrect'. Then we calculated the number of students who gave correct answers and presented it in percentage. The percentage was intended to provide an overall overview of students' understanding of linear equation. Lastly, we looked deeper into the students answers to analyze how the students correctly or incorrectly answer the questions.

RESULTS AND DISCUSSION

Results

In this section, students' understanding of linear equation is presented based on their answers to the test questions. The questions are as follow.

Question 1 (Q1) Zakat obligation in West Aceh in 2019 is 1.5 *bambu* of rice per person (*bambu* is the traditional measurement of rice in Aceh, it is equal to 1.5 kg). Mr. Asrul and Mr. Faiz paid zakat for their respective family. Mr. Asrul paid twice as many as Mr. Faiz. If the total amount of zakat from the two families was 18 *bambu,*

a. How many *bambu* did each Mr. Asrul and Mr. Faiz pay?

b. How many persons are there in Mr.Faiz's family?

Question 2 (Q2) Arabica Gayo coffee is the internationally acclaimed coffee from Takengon, central Aceh. There are 2 kinds of Gayo coffee available in the market, they are Specialty and Luwak. The prize of Specialty is Rp190,000 per *bambu*, and the prize of Luwak is Rp840,000 per *bambu*. If a buyer bought 5 *bambu* of Gayo coffee and paid Rp2,250,000, how many *bambu* did he buy for each Specialty and Luwak?

Question 1 is a one-variable linear equation problem, and question 2 is a two-variables linear equation problem. As mentioned in the Method section, in solving the problems, students' understanding of linear equation concept was assessed by their ability to translate the problems into linear equation, perform accurate calculation, and present the correct final answer to the problems. Table 1 below shows the number of students who gave correct answer to the problems.

Table 1. Students' Answers

No.	Aspect	Number of Students		Percentage	
		Q1	Q2	Q1	Q2
1	Correctly translate word problems into linear equation.	91	93	86.7	88.6
2	Perform calculation correctly.	86	89	81.9	84.7
3	Give correct final answer.	86	89	81.9	84.7

It is apparent in Table 1 that majority of the students could solve the word problems related to linear equation after experiencing learning using ethnomathematics teaching material. For the first aspect of solving the problems, which is translating the problems into linear equations, 91 out of 105 students or 86.7% correctly produced the equation for question number 1, and 88.6% for question number 2. In performing calculation involving numbers and operators, 81.9% students could perform correct calculation for question number 1, and 84.7 % for question number 2. Lastly, 81.9% students ended up with the correct answer for question number 1, and 84.7% students presented correct final answer for question number 2. Figure 2 below shows a student's correct answer to question 1a.

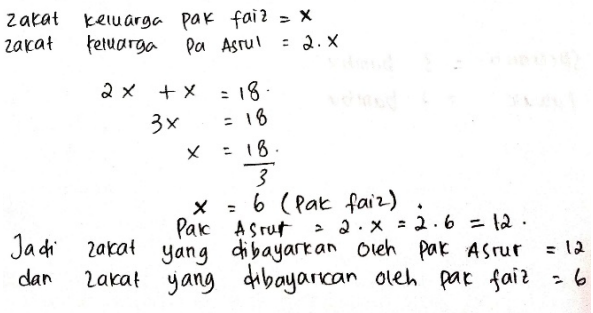

Figure 2. A Student's Answer for Q1a

Figure 2 exposes the student's good understanding of the problem. She correctly assigned a variable x to represent an unknown

quantity and produced the linear equation. Then, by manipulating the equation accurately, she found the value for x and finally ended up with the correct answer.

Majority of the students could answer question 1 correctly. Only a few students answered incorrectly. Figure 3 shows a student's incorrect answer to question 1b.

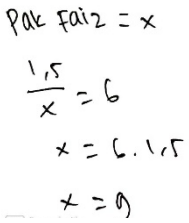

Figure 3. A Student's Answer for Q1b

The student previously answered question 1a correctly that Mr. Faiz paid 6 *bambu* of zakat. To answer question 1b, the student should have divided 6 by 1.5 which would give him the correct answer of 4. Instead, he multiplied 6 by 1.5 and ended up with 9, which is a wrong answer to question 1b.

In performing mathematical calculations for question 2, majority of the students calculated correctly. However, there were few students who made errors in their calculation. Error in calculation resulted in a wrong answer as shown in Figure 4.

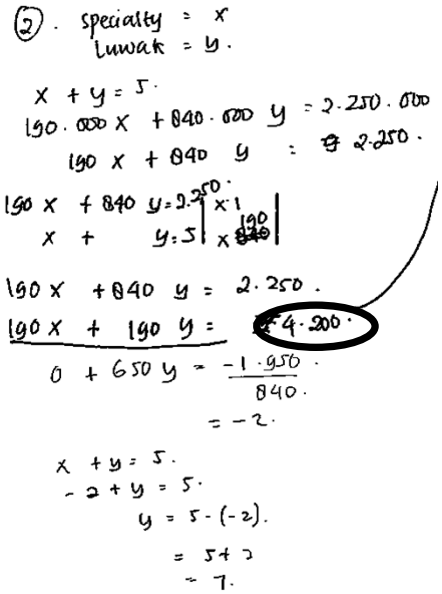

Figure 4.A Student's Answer for Q2

As seen in Figure 4, the student initially produced the correct linear equation with two variables for question 2. But in solving the equation, she miscalculated the product of $5x190$ and wrote down 4200 (circled in Figure 4) instead of the correct answer which is 950. This miscalculation could not lead her to the correct final answer to question 2. The correct answer for the question is $x = 3$ and $y = 2$. But because of miscalculation, the student answered $x = -2$ and $y = 7$.

As stated earlier, question 1 is a one-variable linear equation problem and question 2 is a system of two-variable linear equation problem. Figure 5 below describes the average percentage of students answer to question 1, and Figure 6 describes the average percentage of students' answer to question 2, based on the three aspects shown in Table 1.

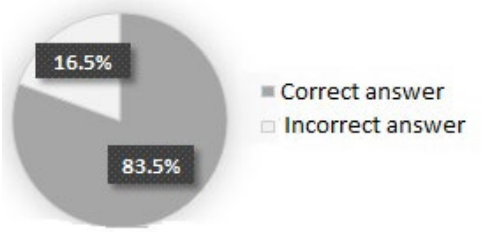

Figure 5.Students' Answer for Q1

Figure 6.Students' Answer for Q2

Figure 5 shows that the percentage of students who could answer question 1 is 83.5% and Figure 6 shows that the percentage of students who could answer question 2 is 86%. Even though question 2 is relatively more difficult than question 1 because question 2 has more variables and more equations and therefore requires more complex calculation, but the percentage of students who could answer question 2 is also high as the percentage of students who could answer question 1.

DISCUSSION

In this section, we present the discussion for our findings. First of all, it is apparent in Table 1 that for every aspect of the problem-solving, at least 81.9% of the students performed well. This finding shows that the implementation of ethnomathematics teaching material successfully helped majority of the students understand linear equation. This finding is in line with a number of studies which reveal the benefit of ethnomathematics for student learning (Rossa & Orey, 2011; Setiyadi et al., 2018). The implementation of ethnomathematics teaching material helps clarify the abstractness of linear equation using cultural contexts that are familiar for the students. Abramovich et al. (2019) suggest that students' familiarity with mathematics is

crucial as it offers the sense of meaningful learning experience. This is as Wittek and Habib (2013) emphasize that a quality learning experience leads to good understanding of a concept.

Undeniably, there were few students who did not perform well during the test. For the first aspect, which is translating word problems into linear equation, 13.3% could not perform correctly. The students' answer sheets revealed that the students had difficulties in understanding word problems and in identifying the unknown quantities in the problems. This finding is in line with previous studies that show that many students are struggling with unknown quantities and variables in an equation (Jupri, 2016). Lack of experience with word problems may be the main cause for students' difficulties in solving word problems. In fact, this finding emphasizes the importance of familiarizing students with word problems because it is a good way to promote students' construction knowledge of mathematics. Powell and Fuchs (2018) suggest that word problems promote vital skills that students need in their life such as preciseness and careful reasoning. A teacher can utilize ethnomathematics in their teaching as a way of presenting mathematical formulas and equation into familiar cultural context in the form of word problems.

Another aspect of solving a linear equation is conducting calculations that involve numbers and mathematical operators. The implementation of ethnomathematics in mathematical calculation can help students make sense of numbers and operators and their connection in an equation. Noviyana et al. (2020) suggest that ethnomathematics teaching material helps improve students' mathematical connection and communication skills. Figure 1 gives an example of a student's understanding of the connection between numbers and variables in the equation. She correctly assigned a variable to represent the specific unknown number and then carried out accurate calculation to solve for the variable. On the contrary, Figure 3 shows a miscalculation of numbers. Errors in calculations may be caused by carelessness or misconceptions (Tong & Loc, 2017). Carelessness in calculation can be referred to as the behavior of not conducting calculation carefully therefore the results tend to be false. This behavior can be diminished by getting used to work carefully. A more serious problem and more difficult to solve is misconception. Aygor dan Ozdag (2012) argue that misconception is a primary factor of students' poor achievement in mathematics. Misconceptions need to be addressed as soon as possible otherwise they may hinder students' success in mathematics (Khalid & Embong, 2019; Ojose, 2015).

Another cause for errors in calculation is unawareness of one's errors (Tong & Loc, 2017). Actually, the cultural context within question 2 in the test should trigger the student's awareness that the context of buying Gayo coffee should not result in negative numbers. The amount of purchase cannot be in negative numbers. Apparently, the student carried out calculation without carefully paying attention to the context of the calculation. This problem hopefully can be resolved by continuing the implementation of ethnomathematics in the teaching and learning of mathematics. This is as (Mania & Alam, 2021) suggest that ethnomathematics can help students appreciate mathematical activity as part of their daily life, not just a meaningless calculation.

The third aspect of solving a linear equation is giving the final answer to the equation. This seemingly given aspect is actually an important aspect of problem solving. Polya proposes that the concluding step of problem solving is re-checking the final answer (Lee, 2017). Mathematics teachers around the world probably have witnessed how students sometimes perform correct calculation in solving a problem but eventually fail to write down the correct final answer. This is as reported by Hariati and Septiadi (2019) that students often make mistakes in writing the final answer to a linear equation problem. This may be caused by carelessness or lack of understanding of a mathematical problem. Teachers' use of word problems should be able to help their students overcome this difficulty because in solving a word problem, the context used in the problem can train students to read problems effectively. Effective reading in mathematics includes constructing meaning, analyzing, connecting and organizing information (Harlaar et al., 2012). By implementing ethnomathematics in linear equation problems, students can connect mathematical expressions and symbols within the equations with cultural context of the equations. This way, students can experience mathematics activity as part of their daily life (D'Ambrosio, 2016).

Judging from the data presented in Table 1, the students correct final answer depends on their correct calculation in solving the linear equation problems. The students who performed calculation correctly were able to present the correct final answer for both questions 1 and 2. This makes sense because the process of solving a problem greatly influences the final answer. Polya proposes that in problem solving, the steps of

designing a solving strategy and carrying out the process precede the step of re-checking the final answer (Lee, 2017). This implies that accuracy in carrying out calculation strategy greatly influences the correctness of the final answer. If there is a case where a student carries out calculation correctly but ends up with a wrong final answer, it may be caused by carelessness.

In comparing students' performance in solving questions 1 and 2, data shows that the percentage of students who could solve both questions were almost the same. As shown in Figures 4a and 4b, 83.5% students could answer question 1 correctly and 86% students could answer question 2 correctly. Question 1 deals with one-variable linear equation, while question 2 deals with two-variable linear equation. Question 1 requires simpler and straightforward calculation, while question 2 requires more complex manipulations of variables such as elimination and substitution strategies. In their review, Otten et al. (2019) summarize that the basic knowledge needed to solve a linear equation problem is the concept of balance or equality. Through the activity of solving a linear equation, a student must keep in mind that the mathematical expressions on the right and left sides of the equal sign have the same value, and then the student should be able to carry out necessary calculation to solve a linear equation problem whether it is with one or two variables.

CONCLUSION

From the findings of this study, it can be concluded that ethnomathematics teaching material improves students' understanding of linear equation through the use of familiar cultural context within linear equation problems. Results show that after being exposed to learning experience using ethnomathematics teaching materials, more than 83% of the students were able to solve linear equation problems. This finding suggests that teacher should utilize ethnomathematics teaching material to help students understand linear equations. For future research, we recommend that cultural aspects to be included in other topics of mathematics.

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