Developing ethnomathematics-based worksheet to teach linear equations

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Abstract. Ethnomathematics-based learning is using local cultural context within the teaching and learning of mathematics. Using ethnomathematics-based learning sources in the classroom can help create a meaningful learning experience. This article reports a design research conducted to develop an ethnomathematics-based worksheet to be used to teach the concept of linear equations. The target users were first-year students of the primary education department of Syiah Kuala University, Indonesia. The development of the worksheet was carried out in three phases which consisted of preliminary research, developing or prototyping and assessment. Data were gathered using validation sheets and observation sheets. Data analysis was carried out qualitatively where the assessment of the product was based on its validity, practicality and effectivity. In this article, we reported the validity and practicality criteria. Several revisions had been made during the development of the worksheet. The end result of the product satisfied the criteria of validity and practicality. These findings suggest that the development of the product can proceed to the assessment phase to test the effectiveness of the worksheet.

1. Introduction
The teaching and learning of mathematics at the Primary Education Department of Syiah Kuala University is aimed at preparing pre-service teachers to be competent school teachers who have in-depth understanding of mathematics and its application. One of the subjects taught at the department is the concept of linear equation. It is an important mathematical concept that honed critical thinking and problem-solving skill [1]. The essence of linear equation is to translate a problem into a mathematical equation so that the problem can be solved mathematically. Students’ understanding of linear equation greatly affects their understanding of other related concepts such as quadratic equation and quadratic function [2].

Considering the importance of students’ understanding of linear equation, it is unfortunate that many students struggle with the concept of linear equation. This is shown by students’ low achievement during examinations over the years. The students do not seem to fully comprehend the procedure of representing verbal problems into mathematical equations. Previous studies reveal that this is a common problem among students and the reasons are lack of understanding of mathematical symbols and unfamiliar contexts [1,3,4]. These findings suggest that in teaching linear equation, teachers should utilize familiar contexts to help create a meaningful experience for students.

Presenting a familiar context within the teaching and learning of mathematics is a crucial factor in mathematics learning [5]. As Mukhopadhyay, Greer and Roth [6] suggest that the use of familiar context as opposed to merely official mathematics in the classroom can help students feel familiar
with mathematical concepts because they can see the application of mathematics in daily life. Therefore they are more likely to be motivated to learn it because they feel the need to understand it [7]. Incorporating ethnomathematics in the classroom is a way to present mathematics in a familiar context.

The word ethnomathematics comes from Greek words *ethno*, *mathema* and *tics* [8]. D’Ambrosio explains that the term ethnomathematics refers to the integration of mathematical activity within the daily life of a society [9]. According to Al-Khwarizmi, mathematics has long been a part of human’s life and will continue to be an inseparable part of human’s history [10]. People always use mathematical activities in dealing with or solving their everyday problem. For example, traders use arithmetic to calculate prices, benefits, and losses; construction workers use geometry to build a strong construction; traditional artists make use of reflection or mirror image to create beautiful arts; and so on.

In mathematics education, implementing ethnomathematics means connecting mathematics with students’ social culture [7]. Previous studies reveal that implementing ethnomathematics is beneficial for student learning [8,11,12]. Through ethnomathematics-based learning, students can appreciate mathematics as part of their daily experience in the community [11]. Similarly, Rosa and Orey [8] suggest that the implementation of ethnomathematics can improve students’ positive attitude toward mathematics and improve their learning outcomes. Ethnomathematics can also improve students’ appreciation of local culture and affect the way they behave in their society [12].

The implementation of ethnomathematics in the classroom can be done by presenting mathematical problems in local contexts [11]. Several studies have reported the implementation of ethnomathematics-based worksheets in mathematics learning to improve students’ critical thinking and problem-solving skill [13,14]. Unfortunately, in the Aceh province, Indonesia, there has been no publication on the topic of ethnomathematics especially in the teaching and learning of linear equation. Therefore, this article intends to report a study conducted to develop an ethnomathematics-based worksheet to be used to teach linear equation for pre-service teachers at the Primary Education Department, Syiah Kuala University. The goal was to develop a worksheet that satisfies the validity, practicality and effectiveness criteria. In this article, we report the validity and practicality of the worksheet.

2. Method
This study employed research and development approach (R & D) based on Plomp’s development stages which consisted of three phases: preliminary research, developing or prototyping, and assessment [15]. These three phases are shown in Figure 1.

![Figure 1. The development phases of ethnomathematics-based worksheet.](image)

As shown in Figure 1, the first stage of the development was preliminary research. In this stage, analysis of curriculum and students were conducted. The result of the analysis served as the base frame for the development of the worksheet. In the developing phase, the prototype of the worksheet
was designed to fit its target users: first-year students at the Primary Education Department of Syiah Kuala University. Validation of the prototype was also conducted during this phase. Revisions were made until the prototype satisfies the validity criteria. In the assessment phase, the prototype was tested on the target users. In this article, we reported the minor-scale trial involving 6 students. During the trial, students’ learning activities and responses toward the use of the prototype were recorded to assess the practicality of the worksheet.

Data analysis was conducted qualitatively based on the validity and practicality of the product [16]. The validation carried out in this study focused on content validity, which measured the coverage of the worksheet in terms of construct-relevant items, format, and language appropriateness [17]. Three content experts were invited to validate the worksheet using a 4-point Likert scale ranging from Very Good = 4, Good = 3, Average = 2, and Poor = 1. The prototype was considered valid if the validation score was equal to or greater than 0.6 [18].

The practicality aspect refers to the benefit and ease-of-use of the product [16]. The measurement was based on students’ learning activity during the implementation of the product and the students’ responses toward the product. Data on students’ activity were gathered using an observation sheet, and data on students’ responses were gathered using a questionnaire. The product was considered practical if students’ activity was in the Good category and students’ responses was positive toward the implementation of the product.

3. Results and Discussion
This section is divided into three parts: part 1 preliminary research, part 2 developing or prototyping, and part 3 assessment.

3.1. Phase 1 – preliminary research
The preliminary research resulted in the formulation of learning objectives based on curriculum and student analysis. Based on the mathematics curriculum used at the Primary Education Department of Syiah Kuala University, the concept of linear equation is taught to first-year students during the first semester. The content covers linear equation with 1 variable and systems of linear equation with 2 variables. The learning objectives are: students can solve systems of linear equations by elimination and substitution, and students can solve contextual problems or daily-life problems involving linear equations.

Students’ analysis revealed that 90% of the target users were Acehnese. They were born and raised in various districts of the Aceh province including central Aceh, west Aceh, east Aceh and the capital town Banda Aceh. Therefore the development of the ethnomathematics-based worksheet should incorporate Aceh culture. This would also benefit the other students from other ethnicities because they could learn about Aceh culture.

The students’ average age was 19 years old which meant that the teaching and learning can be categorized as andragogy [19]. According to Knowles there are several important assumptions of andragogy: the students need acknowledgement of their achievement, they have enough life experience that they can discuss and share, and the teaching and learning should be designed to prepare students to be able to cope within their community [19].

Based on the curriculum and student analysis, it was established that the development of the ethnomathematics-based worksheet was aimed at producing a worksheet on linear equation that incorporated Aceh culture, promoted student discussion and improved student understanding of the implementation of linear equation in daily life.

3.2. Phase 2 – developing or prototyping
The initial prototype of the ethnomathematics-based worksheet was designed and was validated by 3 mathematics education experts. The validation score was calculated using the Aiken’s formula [20].

$$ V = \frac{\sum s}{n(c-1)} $$

(1)
where \( V = \) validation score, \( s = \) the score given by validator – the lowest score in Likert scale, \( c = \) the highest score in Likert scale, and \( n = \) the number of validators. Table 1 shows the validation scores for the first and second validation tests.

### Table 1. Validation scores.

| Assessment Aspects | First-round Score | Second-round Score |
|--------------------|-------------------|--------------------|
| Content            | 0.47              | 0.67               |
| Format             | 0.52              | 0.63               |
| Language           | 0.67              | 0.67               |

As shown in Table 1, for the first-round of the validation, the score for two aspects was lower than 0.6. The validators remarked that the questions on the worksheet were too wordy and confusing. Therefore revisions were made to simplify the language of the questions. For the format aspect, the validators suggested the images on the worksheet to be made clearer. After revisions, the validation score for the worksheet was greater than 0.6 for the content, format and language aspects. Therefore the worksheet has satisfied the validity criteria. Figure 2 shows a part of the validated worksheet.

#### Discussion 2.

Read the following word problems carefully and solve them. Discuss with your group members and present your work in front of the class.

1. Mats made from pandan is famous souvenir from Aceh. Mrs. Fitri is a mat artist. The following figures shows a mat that Mrs. Fitri makes.

   ![Image of a mat](image)

   It costs Rp55,000 a piece. If Mrs. Fitri receives an order worth Rp660,000, how many mats does she have to make?

   **Answer**

   Suppose \( x \) states the amount of mats that Mrs. Fitri has to make, then the equation is \( 55,000 \times x = 660,000 \)

   \[ x = \frac{660,000}{55,000} = \ldots \]

   Therefore, the number of mats that Mrs. Fitri has to make is \( \ldots \) pieces.

2. The people of central Aceh use the term mok, bambu, and kaleng to measure rice. 6 mok = 1 bambu, and 10 bambu = 1 kaleng.

   ![Image of rice](image)

   Mrs. Ila sells two types of rice in the market in Takengon, central Aceh. She sells rice Rongka Rp170,000 per kaleng and rice Pegasing Rp160,000 per kaleng. If she managed to sell 6 kaleng of rice today worth Rp996,000, how many each rice Rongka and rice Pegasing that she sold?

   **Answer**

   Let \( x \) = ....

   \[ y = \ldots \]

   Then, the system of linear equation is:

   \[ \ldots \]

   It will be solved using the method of elimination/substitution as follow.

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**Figure 2.** An extract of the ethnomathematics-based worksheet.
3.3. Phase 3 – assessment

In this subsection, we report the practicality aspect where 6 students participated for a minor trial. As stated earlier, the practicality of the worksheet was based on students’ learning activity and students’ responses. For students’ learning activity, the observation focused on student attention and student interaction. The activity was assessed by 2 observers using a 3-point Likert scale ranging from Good = 3, Average = 2, and Poor = 1. Good category means that more than 70% of the students conducted the activity; Average means that 50% - 70% of the students conducted the activity; and Poor means that less than 50% of the students conducted the activity. Table 2 shows the result of the observation.

| Observation Items                  | Good (3) | Average (2) | Poor (1) | Mean |
|------------------------------------|----------|-------------|----------|------|
| Student pay attention              | 2        | 3           |          |      |
| Discuss with group members         | 2        | 3           |          |      |
| Work together in group             | 2        | 3           |          |      |
| Help/ask for help from group members | 2        | 2           |          |      |
| Stay on task                       | 2        | 3           |          |      |

As seen in Table 2, both observers appraised that students’ learning activity was in Good category. The mean score for most of the items was 3. The lowest score was for the fourth item, which was helping/asking for help from group members (mean = 2). Overall the students paid attention during learning, they discussed with their group members during group task, they worked together not depending on a single student to finish the task, and they stayed on task throughout learning. This finding is in line with Faridah’s study which found that when students were taught in a familiar context, they would be more likely to focus during learning and stay on task [5].

The data on students’ responses toward the implementation of the ethnomathematics-based worksheet was gathered through a questionnaire. The students were asked to assess the worksheet in terms of its content, picture, and the questions using a 4-point Likert scale: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2 and Strongly Disagree = 1. Table 3 shows students’ responses toward the worksheet.

| Items No | Score | Mean |
|----------|-------|------|
| 1. The instruction is complete and easy to understand. | SA 6  | 4.00 |
| 2. The language of the worksheet is clear and readable. | A 5  | 3.83 |
| 3. The language is easy to understand. | A 4  | 3.17 |
| 4. The pictures on the worksheet are clear. | D 4  | 3.67 |
| 5. The questions match the topic. | D 6  | 4.00 |
| 6. The questions are easy to understand. | A 5  | 3.83 |
| 7. The cultural context helps me understand linear equation. | D 4  | 3.67 |
| 8. The cultural context makes me interested to learn. | D 4  | 3.67 |

Table 3 shows that the students’ responses toward the ethnomathematics-based worksheet were positive. Most of the students strongly agreed or agreed with the items on the questionnaire. The highest mean score was for items 2 and 6, and the lowest mean score was for item 3. In general, the students agreed that the worksheet helped them understand linear equation. This is important because students’ view on a teaching approach or teaching materials influences their attention and participation in class [21]. Based on the data that students’ learning activity was in Good category and that students’
responses toward the worksheet were positive, then it could be established that the ethnomathematics-based worksheet satisfied the practical criteria.

4. Conclusion
The development of the ethnomathematics-based worksheet for the topic of linear equation has met the validity criteria. The validation score was 0.67 for the content aspect, 0.63 for the format aspect, and 0.67 for the language aspect. Students’ learning activity while using the worksheet was in Good category, and the students’ responses toward the worksheet were positive. Therefore the worksheet has also met the practical criteria. These findings imply that the development of the ethnomathematics-based worksheet can proceed to the next step. The next step is the assessment phase which is conducted to investigate the effectiveness of the worksheet by assessing students’ learning outcome.

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