Developing ethnomathematical tasks in the context of Yogyakarta to measure critical thinking ability

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Abstract. One of the students' abilities in learning mathematics is the critical thinking ability, which can be developed by giving tasks of mathematics problems. This research aimed to develop and produce valid and practical ethnomathematical tasks within the context of Yogyakarta that may potentially improve students' critical thinking abilities. This type of research was design research using development studies. This research was conducted at a junior high school in Yogyakarta, Indonesia. The research participants were 24 eighth grade students. The data collection instruments were validation sheets, questionnaires, and ethnomathematical tasks within the context of Yogyakarta. The research data was analyzed descriptively. The results show that the ethnomathematical tasks within the context of Yogyakarta were valid, practical, and can potentially measure the critical thinking skills.

1. Introduction

Critical thinking ability is one of the learning goals from Permendiknas No. 20 of 2006 which declared a new standard of graduate competence. It is obtained through learning experiences, especially in science and technology courses. Mathematics is a subject of science and technology [1]. Therefore, it is able to facilitate students’ critical thinking abilities.

Critical thinking is a person’s intellectual ability to understand mathematical problems. [2]. Through critical thinking, they have the ability to solve problems, analyze problems well, and make reasonable and consistent decisions [3]. In learning activities, this ability must be developed so that it becomes habit and part of one’s character to deal with various problems in real situations. As Istianah said, students must master critical thinking skills because they will be expected to be able to solve problems in a constantly changing world [4].

Critical thinking is closely related to mathematical problems. To solve mathematical problems requires knowledge of mathematical material, knowledge of problem solving strategies, effective self-monitoring, and a productive attitude to address and solve problems [5]. In the other words, critical thinking steps are needed to solve mathematical problems. This is reinforced by Stanick and
Kilpatrick’s statement that problem solving is the core of mathematics because it requires the ability to think critically [6].

Although critical thinking skills are very important. But the fact, many Indonesian students have not been able to master this ability properly. Students’ critical thinking skills are quite low [7-8]. There is an effort to develop students’ critical thinking skills by giving exercises in the form of mathematical problems that require critical thinking skills. Therefore, it is necessary to develop rigorous problem solving questions that facilitate the development of such skills.

Mathematical problems are contextual questions. In other words, mathematics questions usually include story problems that discuss everyday issues. These problems do not have known routine procedures and use certain rules and concepts of analysis in the solution [9,1]. The use of context analysis has several objectives, namely: concept formation; model formation; providing tools for thinking using procedures, notations, drawings and rules; using reality as a source and application domain; and training specific abilities in certain situations [10-11]. One context that can be used is culture, so the concept is to link mathematics and culture to the environment of students. This concept is called ethnomathematics [12-13]. The research utilized the culture of Yogyakarta as a reference for developing mathematical problems based on ethnomathematics.

This mathematical problem was designed to measure critical thinking skills. So, the solving steps were designed to be indicators of critical thinking skills. In this study, the critical thinking indicators used are: (1) the ability to provide simple explanations, (2) the ability to provide further explanation, (3) the ability to determine settlement strategies, and (4) the ability to make conclusions and (5) evaluations [14-15]. The aim of this research was to develop an ethnomathematics-based mathematical problems in the context of Yogyakarta to measure critical thinking skills.

2. Method

This type of research was design research using development studies. It was adopted from Tessmer, which consisted of two stages: the preliminary stage (preparation and design of mathematical problem) and formative evaluation stage (self-evaluation, expert review, one-to-one, small group and field test) [16-17]. The participants of the study were involving 24 students of grade VIII E from SMP Negeri 1 Piyungan Yogyakarta. The instruments used in the study consisted of validation sheets, questionnaires and ethnomathematical tasks with pertaining to geometry. Validation sheets assessed the validity of the questions, while tests and questionnaires were used to see the practicality and potential effects of the ethnomathematical tasks [18]. The research data was then analyzed descriptively.

3. Result

3.1. Preliminary Stage

At the preliminary stage, researchers conducted analyses of students, the curriculum, the context of ethnomatics, and concepts in developing critical thinking problems. At this stage, the researchers produced the research apparatus: a validation sheet and questionnaire with ethnomathematic problems on the geometry material. The next step is to self-evaluate the problem. In this case, the researcher is assisted by a peer lecturer who has had research experience related to critical thinking. The final result of this stage is prototype 1.
3.2. Expert Review.

Prototype 1 was validated by lecturer in mathematics education from Yogyakarta State University. The validators evaluated the ethnomathematical questions that were thoughtfully constructed with mindful content, clear language, and indicators of critical thinking. However, there were still comments of possible improvements, but only minor revisions.

3.3. Preliminary Stage

Upon completion of validation, the questions were given to 3 students, or the control group. This was to check the legibility, clarity of information, images, and so on; it was not to examine how they solve the problem. The purpose of this stage was to locate any possible difficulties in the understanding of questions. Students’ comments from this stage were used to improve Prototype 1. Prototype 1 revision results are called Prototype 2.

3.4. Expert Review.

At this stage, researchers asked 6 students to work on and comment on the questions. The students commented that all questions were clear and easily understood. From this, it can be concluded that the developed test questions were practical and unambiguous.

3.5. Preliminary Stage

Field tests were the last stage in this study. Documents produced at this stage were student answer sheets and interview results. There were 24 students of class VIII E of SMP Negeri 1 Piyungan who were involved in this stage. While solving the test questions, students were asked to write the answers based on steps according to the indicators of critical thinking. The results of the field tests were analyzed to discover the potential effects of the questions that have been developed. Conclusions from the implementation of the field test are test questions that utilize and measure students’ critical thinking abilities. This is due to test questions being able to measure students' critical thinking abilities

4. Discussion

The fifth development process aims to obtain ethnomathematics-based test questions in the context of Yogyakarta that are valid, practical, and utilize and measure students’ critical thinking abilities. Test questions consist of 5 geometry problem solving questions. The context is ethnomathematics in the city of Yogyakarta, Indonesia. The ethnomathematics context includes traditional Yogyakarta housing, Prambanan Temple, Pathok State Mosque, batik of Yogyakarta, and part of the king's building, the Keraton of Yogyakarta.

After the preliminary stage, the test questions were validated by experts, meaning that the questions’ content, construction, and language were all satisfactory. In addition, the questions fulfilled indicators of critical thinking. As Hadi stated, if the theory building (construction) is correct, then the results with a measuring instrument based on that theory will have valid results [19]. The critical thinking indicators used include (1) the ability to provide simple explanations, (2) the ability to provide further explanation, (3) the ability to determine settlement strategies, and (4) the ability to
make conclusions and (5) evaluations. However, there are still some minor comments and suggestions for improvement, but they are mostly minor revisions.

Practical elements are obtained after the stages one-to-one and small group. Based on observations and comments from students, all problems were clear and easy to understand [16,17]. Furthermore, after the questions were deemed valid and practical, the field test was performed to see the potential effects of the problem. Based on the results of the answers and interviews, the results showed that most students were able to demonstrate indicators of critical thinking. Students systematically wrote down the problem solving steps. Data on students’ critical thinking ability are presented in the following table:

| No | Critical Thinking Indicator                                           | Percentage of Correct Answers |
|----|-----------------------------------------------------------------------|-------------------------------|
| 1  | Ability to provide simple explanations                                | 90%                           |
| 2  | Ability to provide further explanation                               | 85%                           |
| 3  | Ability to determine settlement strategies                           | 80%                           |
| 4  | Ability to make conclusions                                         | 80%                           |
| 5  | Evaluation                                                            | 70%                           |

In addition, the results of the interviews with research subjects showed a positive response to the problem. As proof that students are able to demonstrate critical thinking skills, the following is an example of a student’s work on Task 3:

Perhatikan atap masjid Pathok Negara Ad-Darojat Babadan seperti gambar berikut, jika diketahui CD = 24 m, BC = 13 m, AB = 34 m, EG = 13 m, EF = 10 m.

Translation: Note, the roof of the Pathok Negara Ad-Darojat Babadan mosque as shown below, it is known CD = 24 m, BC= 13 m, AB = 34 m, EG = 13 m, EF = 10 m.
1. Calculate the area of the shaded area and around the trapezoid.
2. Show other ways to determine the area of the shaded area.

**Problem translation:**
1. Calculate the area of the shaded area and around the trapezoid.
2. Show other ways to determine the area of the shaded area.

**Figure 1.** One question of ethnomathematics

Figure 1 is one of the ethnomathematic questions. The image is Pathok Negara Mosque; the roof of the mosque is a combination of several polygons. Students were directed to answer questions based on critical thinking indicators.

**Figure 2.** Student answer for indicator 1.

Figure 2 shows that students were able to demonstrate the first indicator. Students were able to write down information that is known and pertains to the problem. This is shown by students writing down the measurements from the sides of the polygon and writing down what the question asks.

**Figure 3.** Student answer for indicator 2.
Figure 3 shows that students were able to write mathematical concepts, namely the concept of surface area, triangle area, trapezoid area, and trapezoidal circumference. This proves students were able to show the second indicator of critical thinking:

![Figure 4. Student answer for indicator 3.](image)

Figure 4 shows that students were able to determine solutions or write answers based on coherent, logical steps to be able to find the right answer. This ability is the third indicator:

![Figure 5. Student answer for indicator 4.](image)

Figure 5 shows students were able to demonstrate the fourth indicator of critical thinking skills; they wrote conclusions from their work:

![Figure 6. Student answer for indicator 5](image)
The last indicator is evaluation, or the demonstration of the ability to problem solve in other ways. It was seen that students were able to write down alternative methods to find the area in question. (See figure 6). Based on the result of student work in figure 2 until figure 6, it could be concluded that the problems has potential effect. Because it can to measure students thinking abilities [18], and the ability measured in this study was critical thinking. Therefor, it is very important that the cultural context be used as a learning resource and an instrument to develop thinking skills, especially critical thinking.

5. Conclusion

Based on the results of research and discussion, it was concluded that ethnomathematics-based questions in the context of Yogyakarta were valid and practical criteria. The validity is discovered from validator assessment in validation sheet stating the questions have been good based on content (in accordance with curriculum, the material and also cultural context of Yogyakarta), construct (in accordance with the indicator of critical thinking) and language (in accordance with language rule). The Practical criteria is discovered from the results of student evaluations stating that the questions have been good based on legibility and clarity of information. Also, based on the results in the field test stage, the questions are able to measure students' critical thinking skills (potential effects).

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