The role of ethnomathematics context in learning area of circle

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Abstract

This article describes the role of ethnomathematics context in learning area of circle by decorating bicycle wheels. Decorating wheels using colored paper needs mathematics, and it is one of the ethnomathematics. Using ethnomathematics as a mathematical context supports students' understanding of working in the context of the circle area. The research uses Design Research followed by the Gravemeijer model. The phases of this research are developing preliminary design, validating hypothetical learning trajectories in teaching experiments, and evaluating learning design using retrospective analysis. Hypothetical learning trajectories consist of learning purposes, student activities using ethnomathematics context to develop student understanding on circle area, and conjecture of student thoughts. The teaching experiment results show that ethnomathematics' context contributes to students' grasp of concepts in a more concrete way, and design contributes to instructional theory on the circle area.

Keyword: *The circle area, RME, the role of context*

1. Introduction

Realistic Mathematics Education suggests that teachers have to teach mathematics meaningfully. It means that mathematics should be taught in a certain way so that it is not a ready serve material. Students need to try an activity to get mathematics. Concept and procedure not be delivered as formal knowledge, but it is designed as rediscovering knowledge for very intuitive to student own knowledge. To facilitate the theory, Freudenthal gives a corridor in teaching mathematics. Mathematics develops from human occupation, so if teachers want students to understand their learning, they should do mathematics in a real situation (Freudenthal, 2006). To construct mathematics experientially real to pupils, mathematics should be taught in contextual problems. Contexts play an important role in teaching and learning mathematics.

The learning context becomes a kind of environment that makes students feel real to problems so that it is easier to solve problems (Van den Heuvel-Panhuizen, M., 1999). In this case, the context makes the problem becomes easier to understand. Many situations in the real world can be used as context. One of which is ethnomathematics, mathematic is practiced by groups and expressed in language codes (Nursyahidah, F. A., Ulil, I., & Saputro, B. A., 2020).

Several researchers focused on ethnomathematics, although only a small number of them use ethnomathematics as a context in learning mathematics, especially using RME. Risdiyanti and Prahmana (2017) were exploring batik as a potential material in learning geometric transformation. They suggested that batik can be a good starting point in learning geometric transformation. Widada et al. (2019) also indicated that ethnomathematics could support students' cognition. Even though many contexts could be used in the learning, the teaching of the circle area used a mechanistic approach. This article will show how context plays a significant role in teaching area of circle.

2. Theoretical framework

Approach in teaching mathematics according to Realistic Mathematics Education (RME) Principles are: 1) mathematics should be reinvented by students themselves through reconstruction activity of mathematical notions and ideas beneath the teacher guidance, 2) the activity given to students should be investigated to phenomenologies (or didactical phenomenology) in that way Freudenthal (Sembiring, R. K., Hadi, S., & Dolk, M., 2008) argued specific approaches can be generalized, and to an archetypal solution, algorithm can be chosen as the foundation for developments of standard mathematics, 3) solution of didactical phenomenology made by students will vary depend on their own informal knowledge, so it needs a model to led students generalized informal to a formal mathematic solution.

Following the RME principle, teaching of the circle should be given in activity that concept of circle area is not ready-made. So far, the teaching of the circle area is still carried out by centering on the teacher, where students are given the concept of the circle area instantly or directly by the teacher. Students only get a little idea, so that they have to use it so that students have difficulty understanding the circle area. The statement is following the opinion expressed by Budiyono, A., Kusumaningsih, W., & Albab, IU (2019), states that one of the dominant factors that cause less optimal understanding of the concept of the circle area is that teachers are still conventional in delivering Circle material to students.. This conventional method has an impact on learning that is considered less than optimal, and students tend to have difficulty understanding the concept of the circle area.

Area of circle is one of the materials in mathematics class VIII SMP. Area of circle concept has many useful things in everyday life, making holes, closing circle holes, making wheels, making glasses, buckets, bowls, plates with circular surfaces, and many other utensils that contain circular elements (Emilya, Darmawijoyo, & Ilma, 2010). Therefore, it would be nice if the teaching on the circle area starts from a real context for education's various benefit because it is closed to students.

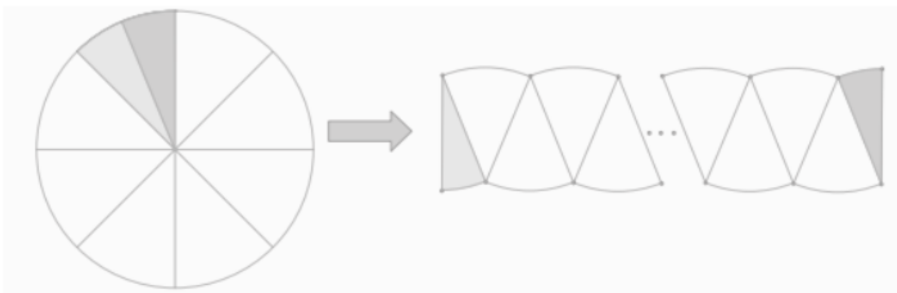
Context plays a significant role in learning mathematics as suggested by Van den Heuvel Pan Huizen where context enhances accessibility to the problem situation used in learning, contributes to transparency and elasticity of the problem, and context suggests strategies. Here, we can understand that these three context roles will be criteria in how problems are useful context or not (Nursyahidah, F. A., Ulil, I., & Saputro, B. A., 2020).

Ethno-mathematics is mathematics that practices by people in particular ethnic groups. Using ethnomathematics as a mathematical context in learning circle area is in line with the idea of Freudenthal (Nursyahidah, F. A., Ulil, I., & Saputro, B. A., 2020). He said that mathematics is a human-being activity, so we need activities to teach them mathematics. Ethnomathematics can be found in groups of people in any place including ethnics groups, farmers, anglers, or even in groups of ages. In this article, the writers focus on ethnomathematics practices by teenagers of Indonesian decorating bicycle wheel on Indonesian Independence day. The way students cover the wheel using colored paper will be a good context in the learning circle area.

Besides the importance of context, teaching mathematics can not be separated from the role of model. The model plays as a bridge between informal knowledge or solutions of students to formal or standard mathematics solution as we know in school as mathematics formulae (Albab, I. U., Hartono, Y., & Darmawijoyo, D., 2014). Although, in this article, writers emphasize the role of context in teaching circle area, the bridging model in learning circle needs to be explored. Model to construct student formal knowledge comes from the idea of circle area proof far ancient Greeks. The initial proofs of the area of circle made by Archimedes (Wilamowsky, Y., Epstein, S., & Dickman, B. (2011). The circle was divided into wedges and the wedges were then put together in order to approximate a rectangle as we can see from Figure 1. Figure 1 shows a rectangular shape from conceiving sectors of a circle. Using the rectangle approach, the area of circle can be calculated from the length times the width of the rectangle. The more we slice the circle, the more accurate "near rectangle" we get. Because the length of the rectangle represents half of the circle circumference, and the radius of circle represents the width of the rectangle, the area of the rectangle is confirmed. Besides using rectangle, this approach can use triangle models. This proof is rather similar to rectangle approach: the circle was divided into wedges and the wedges were then put together in order to approximate a triangle.

Figure 1

The First Proof of Circle Area



Another interesting Proof of circle area is Using n-polygon (Robbins, D. P., 1995) as represented in Figure 2.

Figure 2

Another Proof of Circle Area.

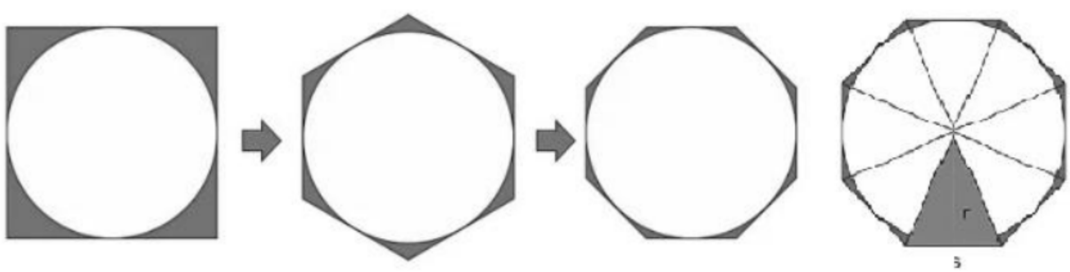


Figure 2 illustrates that the more n-sides of a regular polygon the shape will be closer to the circle. Now if we keep increasing the number of n-sides of the regular polygon then the empty area will get smaller (red color) and get closer to the circle shape. The area of the triangle AOB is 1/2 x base x height = 1/2 x side length x radius. Because the polygon has 8-sides, there are 8 similar triangles so the total area of the 8s is = 1/2 r x 8s. Notice that the 8s represent the side length of the octagon. The number of sides of a regular n-sides polygon will determine the circumference of the circle) so we can replace 8s with 2 Π r and make area of octagon = 1/2 r x 8s be area of Circle = 1/2 r x 2 Π r = Π r2.

The Writers tend to use rectangle proof as a model to bridge students' informal to formal mathematics knowledge developed by students because of two criteria. First, the rectangle model offers more simple proof that students will easy to understand. Second, the rectangle approach will represent the circumference of circle and its relationship to radius simultaneously.

3. Methods

This article is part of the research Design Research after carrying out the third stage, namely retrospective analysis, where the research has three stages, namely preliminary design, teaching experiment, and retrospective analysis. The stages of this research followed the steps suggested by Gravemeijer (2015). The data taken were analyzed using video fragmentation, video transcription, and classification. The teaching experiment results are described to see the role of context in learning the circle area. In this research, Hypothetical Learning Trajectory (HLT) plays a central role (Simon, M. A., & Tzur, R. 2004). HLT which consists of purposes, activities, and students thinking conjecture guide the development of theory, material, and instrument in this learning design.

4. Finding and discussion

Mechanistic learning of the circle area has shown that students learn to memorize the formula for the circle area as A = Pi r ^ 2. This approach has grown in a rigid generation and only good at calculating. By giving slightly different questions made students unable to solve new problems even it is an easy question.

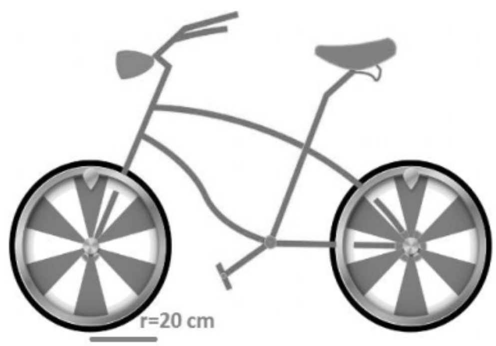
A better development is learning the circle area using a rectangular approach (Budiyono, A., Kusumaningsih, W., & Albab, IU (2019). This study of the circle area divides the circle in small circles and places them in squares. However, the real context has not been shown easily.

Here, using the context of ethnomathematics in celebrating independence day: decorating a bicycle, show how context plays significant role. Freudenthal (Sembiring, R. K., Hadi, S., &

Dolk, M., 2008) suggested teachers should find investigation problems in such a way students can find patterns to solve problems and generelize concept of circle area.

Figure 3

Context in Learning the Area of a Circle

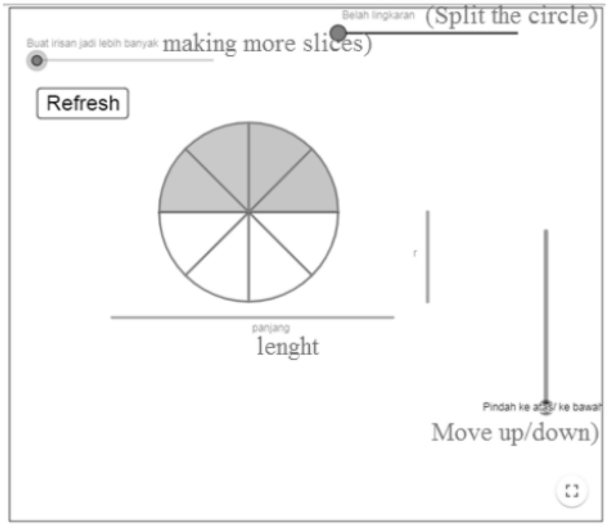
	Indonesia's Independence Day is an annual event organized by all Indonesians. The villages often hold competitions to commemorate Indonesian Independence Day, one of which is decorating bicycles. This image is an example of a bicycle wheel decorated with red and white patterns. If a child is going to decorate his bicycle wheel like that, for one bicycle wheel is enough a folio-sized red paper and white paper?

4.1.Context enhance accessibility to the problem situation used in learning

Decorating bicycle falls into the ethnomathematics because it is practiced by groups, and expressed in language codes (Nursyahidah, F. A., Ulil, I., & Saputro, B. A., 2019). Using this context to learn the circle area helps the students to access the problem situation. Starting from a situation that is easy to imagine, presented visually, students will quickly understand the purpose of the problem.

Figure 4

Problem Presented in Image, Enhance Students Access to the Problem



Visual in Figure 4 is enables all students to understand the purpose of the problem directly. Students know what is given and what is asked.

4.2. Context contributes to transparency and elasticity of the problem

Context problems offer the students more opportunity for demonstrating their abilities and provide more opportunities to demonstrate what they have mastered (Van Den Heuvel-Panhuizen, M., 2005). Figure 5 gives options to the students to make explorations.

Figure 5

A Student Slices Circle becomes Certain Numbers of Sectors, then Splits Them

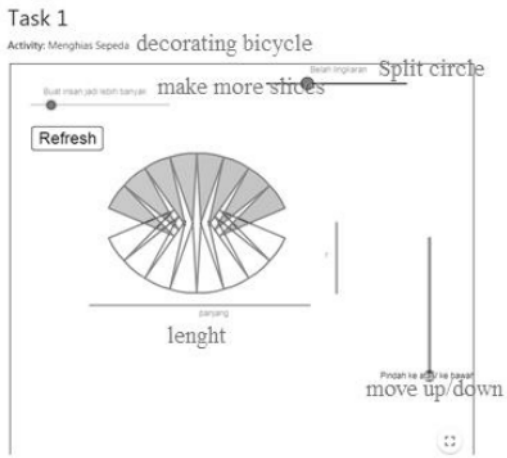
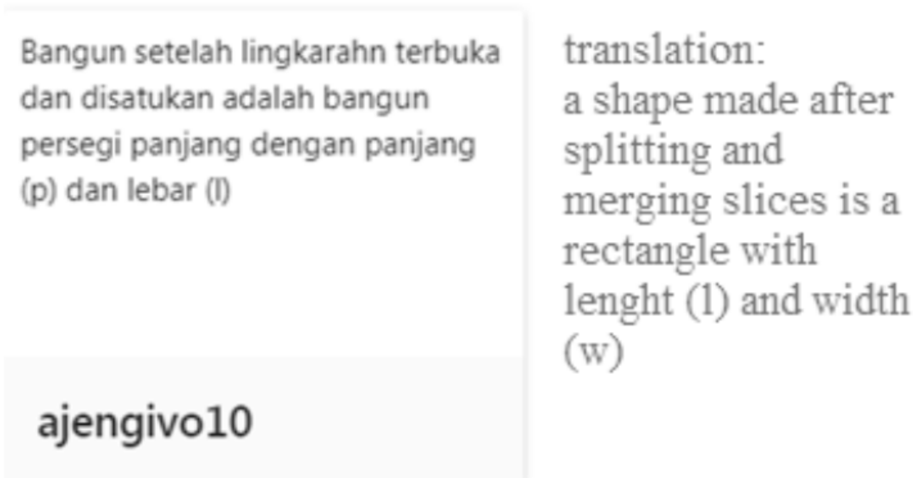


Figure 6

Students Respond to Questions on what Form Made after the Circle is Open



Students split circle in numbers of sectors and then rearrange them to be a rectangle. Students also understand that the smaller the slices, the more precise the rectangular shape is (See Figure 6). It is shown from the activity that students explore the problem in many ways of slices.

4.3. Context suggests strategies

Figure 7

Students Rearrange the Shape of a Circle

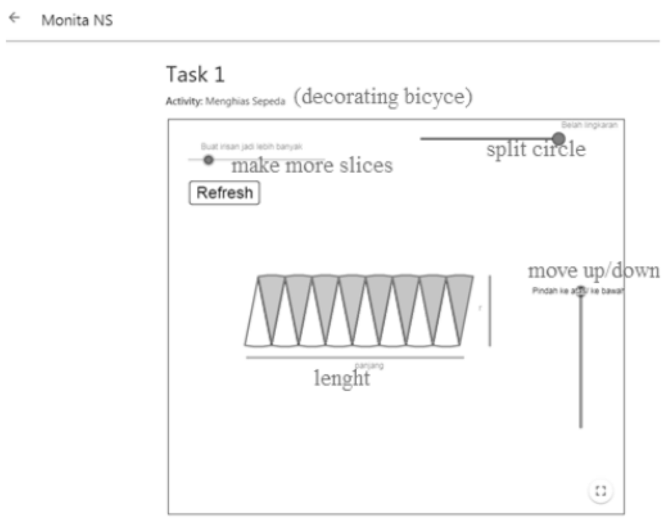
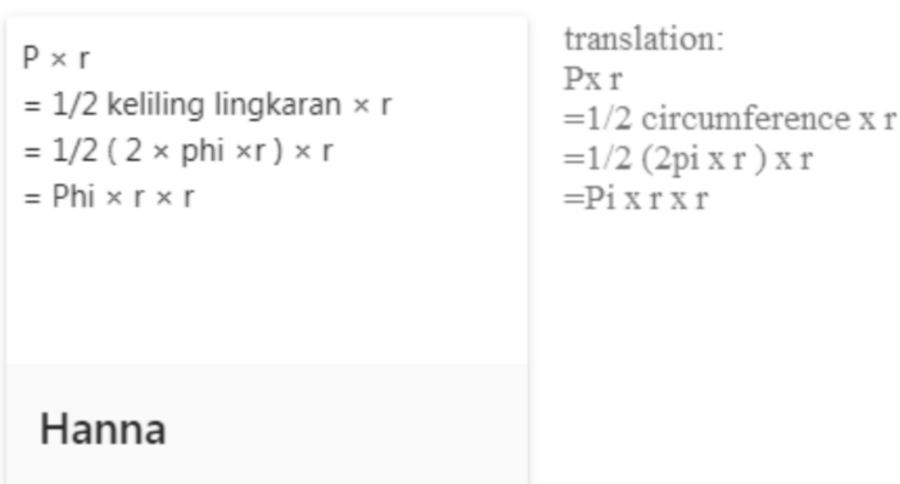


Figure 8

Student Responds to a Question of How to Find the Area of a Rectangle



The context problem provides a hint that the length of the rectangle comes from half of the perimeter, as shown by the students (see Figure 7). The students easily understand the point from the context given. Figure 6 describes that students can find the area of a circle quickly. The rectangle approache is simpler way to find area of circle (Wilamowsky, Y., Epstein, S., & Dickman, B., 2011).

After students find the area of a circle, they compare the area of a circle with two folio sized colored paper areas.

Figure 9

Size of Folio Paper

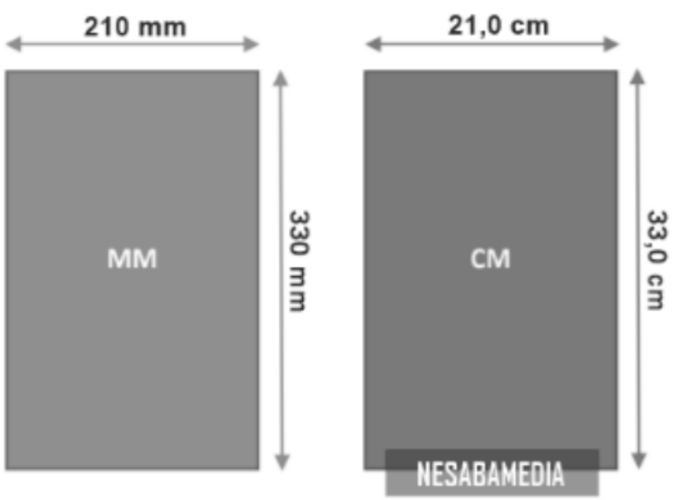


Figure 9 shows that the folio-sized paper has a maximum area of 21*33= 693 cm^2. Two of the paper will not be enough to decorate one wheel as students perform in the discussion. Figure 10 show that students share the idea that two colored paper does not enough to decorate one wheel.

Figure 10

Students ere Comparing the Area of the Wheel to Colored Paper

Luas yang diperlukan 1 buah roda P × r = 1/2 keliling lingkaran × r = 1/2 (2 × phi × r) × r = Phi × r × r = 3,14 × 20 × 20 = 1256 cm	sepertinya akan kurang
Hanna	**Ida**
translation: Area of paper need to decorated one wheel p x r = 1/2 circumference x r = 1/2 (2 x Pi x r) x r = Pi x r x r = 3.14 x 20 x 20 =1256 cm^2	translation: (I think) it will not sufficient

5. Conclusion

Ethno-mathematics context plays a significant role in teaching the area of a circle: context enhances accessibility to the problem situation used in learning, context contributes to transparency and elasticity of the problem, and context suggests strategies.

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