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How does student learn mathematics through traditional food? (a hypothetical learning trajectory)

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Abstract

This study aimed to design a hypothetical learning trajectory for a two-dimensional figure area (quadrilateral and triangle) using the geometric shape of traditional food, *tempe mendoan* as a learning context. This research was qualitative research with data collection methods using literature studies, interviews, and documentation. The subjects in this study were seventh-grade junior high school students in SMP IT Nurul Fikri Bogor. The results of this study are in the form of a hypothetical learning trajectory design in learning the two-dimensional figure area through exploration of Banyumas food *tempe mendoan*, students measure each side of the rectangle from the shape of *tempe mendoan*, students divide the rectangle into square units as many as the results of each measurement side, students counts the number of unit squares that cover the rectangular area, the student finds the formula for the area of a square and a rectangle. Next, students divide one rectangle into two right triangles of equal size, students find the formula for the area of a triangle. Students attach the triangles to the provided two-dimensional figure shapes, students record the number of right triangles needed to cover each shape and find these relationships so that students can find area formulas for other shapes such as parallelograms, trapezoids, and rhombuses.

1. Introduction

Mathematics is known as difficult as subject for students, even though mathematical concepts are closely related to solving problems in human life. People often do not realize that they do application from mathematical concepts in usual activities. Based on the result from observations and interviews, students considered mathematics difficult because formulas and symbols were not understood. It can be caused because learning in schools begins with abstract mathematical concepts. The process of learning mathematics should be taught as a human activity (Freudenthal, 2006).The activity can be in the form of a concrete context in the minds of students so that it does not create a difficulty impression. The approach is in line with such a learning process is the *Pendidikan Matematika Realistik Indonesia* (PMRI) approach which is adapted from Realistic Mathematics Education (RME). RME reform is carried out based on two pillars, ability of teachers to create a problem-oriented classroom culture and invite students to interactive learning, and to design learning activities that can encourage the rediscovery of mathematics (Gravemeijer, 2010).

In this research, learning will be designed using the PMRI approach. So the Hypothetical Learning Trajectory (HLT) that will be compiled is based on the principles and characteristics of Realistic Mathematics Education. The three main principles in Realistic Mathematics Education are guided

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reinvention, didactical phenomenology and self-developed models which contain four levels of model development from situational, model of (referential), model for (general) and finally formal model (Gravemeijer, 1994). Mathematics in the PMRI approach will be presented as a human activity as a form of activity to construct mathematical concepts. Students are given the opportunity to rediscover mathematical concepts through real contexts(Gravemeijer, 2004). Real context in the form of realistic problems. A problem is called "realistic" if the problem can be imagined (imaginable) or real (real) in the minds of students(Van Den Heuvel-Panhuizen, 2003).

The mathematical context used is traditional food of the Banyumas, Central Java, *tempe mendoan*. *Tempe mendoan* is used as a learning activity to rediscover the concept of two-dimensional area. *Tempe* has been known in Indonesia since 1814 AD, as evidenced in the verse of Serat Centini Volume III which says "*Brambang jae santen tempe, asem sambel lethokan*". Fiber Centhini is one of the fibers or ancient records native to the archipelago that mentions the culinary world (Minardi et al., 2021).

Understanding of the mathematical concepts of the manufacturing process and *tempe mendoan* products has been studied before. In this study (Choeriyah et al., 2020) the basic ingredients of soybeans in the manufacture of *tempe mendoan* and triangular *tempe mendoan* were used for mathematical analysis in calculating production results. *Tempe mendoan* products are also used to find geometric concepts such as the number of angles in a hexagon formed by the arrangement of six triangular *tempe mendoan*. Furthermore (Pambudi et al., 2021) used the *tempe mendoan* context to measure students' mathematical reasoning abilities. This study aimed to design a hypothetical learning trajectory for a two-dimensional figure area (quadrilateral and triangle) using the geometric shape of traditional food, *tempe mendoan* as a learning context.

2. Methods

This research was qualitative, with data collection methods literature studies, interviews and documentation. The research was started by designing the HLT based on the results from the literature study and interviews. This research was conducted in class VII SMP IT Nurul Fikri Bogor. Research subjects were selected by purposive sampling technique consisting of 6 students. The research subjects were chosen by considering the diversity of students' mathematical abilities. Criterion A subjects are subjects with low mathematical ability. Criterion B subjects are subjects with high mathematical abilities. Data is collected through the results of student work on worksheets and interviews. The data were analyzed qualitatively to obtain a hypothetical learning trajectory for a two-dimensional figure area (quadrilateral and triangle) using the geometric shape of traditional food, *tempe mendoan*, as a learning context. The HLT that had been designed was then tested on limited respondents, seventh grade in SMP IT Nurul Fikri Bogor. From the results of this limited trial, HLT improvements were then carried out.

3. Results & Discussions

RME is still a research theme of interest in the last four years, due to the success of implementing RME in learning. Previous researches that researched RME with satisfactory results such as (Hasibuan et al., 2018; Pambudi et al., 2021; Laurens et al., 2018; Julie & Gierdien, 2020; Warsito et al., 2019). Treffinger creative learning model with RME principles has a significant effect on the students' creative thinking skill (Ndiung et al., 2019).

Gravemeijer (1994) stated three main principles of RME, such as Guided reinvention/progressive mathematizing, didactical phenomenology and self-developed models. Treffers (in Van Den Heuvel-Panhuizen, 2003) suggested 6 characteristics in RME: activity, reality, level, intertwinement, interactivity, guidance. The principles and characteristics of RME are adapted in PMRI according to conditions in Indonesia. These principles and characteristics become the foundation in developing HLT. HLT is a teaching construction designed by educators as a way to understand students and begin conceptual learning in mathematics(Simon, 2009; Empson, 2011).

HLT "begin with what students bring to their early understanding of target concepts, and identify landmarks and obstacles students are likely to encounter as they proceed from a naïve to a more sophisticated understanding"(Confrey et al., 2017). HLT is structured to facilitate the Basic Competencies:

3.11 Relate the perimeter and area formulas for various types of quadrilaterals (square, rectangle, rhombus, parallelogram, trapezoid, and kite) and triangle
4.11 Solve contextual problems related to the area and perimeter of a quadrilateral (square, rectangle, rhombus, parallelogram, trapezoid, and kite) and triangles.

The HLT design can be seen in Table 1. HLT contains the relationship between levels of development (PMRI), learning paths, activities and learning conjectures. Level of development model refers to (Gravemeijer, 1994), such as situational, model of, model for and formal. Each level is represented by one related activity. Based on the development of these levels, the concept of meaningful mathematics learning is obtained.

Table 1. Hypothetical Learning Trajectory on Quadrilateral and Triangle Areas.

Level of Development Model (PMRI)	Learning Path	Learning Activities	Learning Conjecture
Situational	Finding the properties of a rectangle through the context of *mendoan*	Activity 1: Students cut *mendoan* into rectangles and understand the properties of rectangles	• Students have difficulty cutting *mendoan* into rectangles • The teacher helps students to use a rectangular tool to draw on the *mendoan* before cutting it • Students understand that the results of cutting the edges of *mendoan* are rectangular in shape • Students find the characteristics of a rectangle: It has four opposite sides of the same length, Has two pairs of parallel sides, Has two diagonal lines that intersect each other with the same length, Has four right angles, Has two axes of symmetry , has two rotational symmetries
Model of	Understanding the surface area of a rectangle through a unit square	Activity 2: Students put a red string around the edge of the rectangle and find the concept of the perimeter of the rectangle. Students count the unit square pieces to find the concept of the area of a rectangle	• Students have difficulty putting the red rope • The teacher guides the students so that they can put the rope on the edge of the rectangle • Students discover the concept of a rectangle from measuring rope • Students count the number of unit squares that cover the rectangular area that covers the rectangular area • Students find the formula for the area of a square and a rectangle
Model for	Understand the shape of a right triangle	Activity 3: Students cut the diagonals of the rectangle to produce two right triangles. Students discover the concept of the area of a triangle	• Students have difficulty making diagonal lines • The teacher guides the students to make a diagonal line • Students divide a rectangle into two equal right triangles • Students find the concept of the area of a triangle
Formal	Understand the formula for the area of a two dimension area	Activity 4: Students construct the concept of the area of a parallelogram, trapezoid and kite based on the knowledge they already have	• Students attach the triangles to the provided flat feramework • Students list the number of right triangles needed to cover each plane figure frame

3.1. Activity 1: Finding the properties of a rectangle through the context of mendoan

Activity 1 begins with a philosophical story about the word structure of *mendoan*, which is a typical food of Banyumas. *Mendhak* (down) and *mendhuwur* (up) which means that humans must be careful and skillful in managing themselves, when they are at their peak, they must remain humble, when they are at the bottom they must keep fighting. This philosophy is expected to be a motivation for students in their lives.

Mendoan is used as a situational context from the level of development model (Gravemeijer, 1994). Self-Developed Models serves to bridge the gap between informal knowledge and formal knowledge (Gravemeijer, 1994). Students are instructed to *mendoan* so that they form a rectangle. Students write down the characteristics of the rectangle from the results of the *mendoan* pieces. Alleged difficulties of students are when *mendoan* into a rectangular shape, and mentioning more than one characteristic of a rectangle. The teacher provides guidance to students who have difficulty. Learning mathematics according to the characteristics of guidance, it is necessary to strive so that students have experience in finding their own various concepts, principles or procedures, with teacher guidance. The realization of the characteristics of guidance in statistics learning is the teacher's intervention in providing scaffolding to achieve the Zone of Proximal Development (ZPD) for each student, when students have difficulty solving realistic problems.

Figure 1(a) below is a *Lembar Kegiatan Peserta Didik* (LKPD)/ student worksheet containing activity 1.

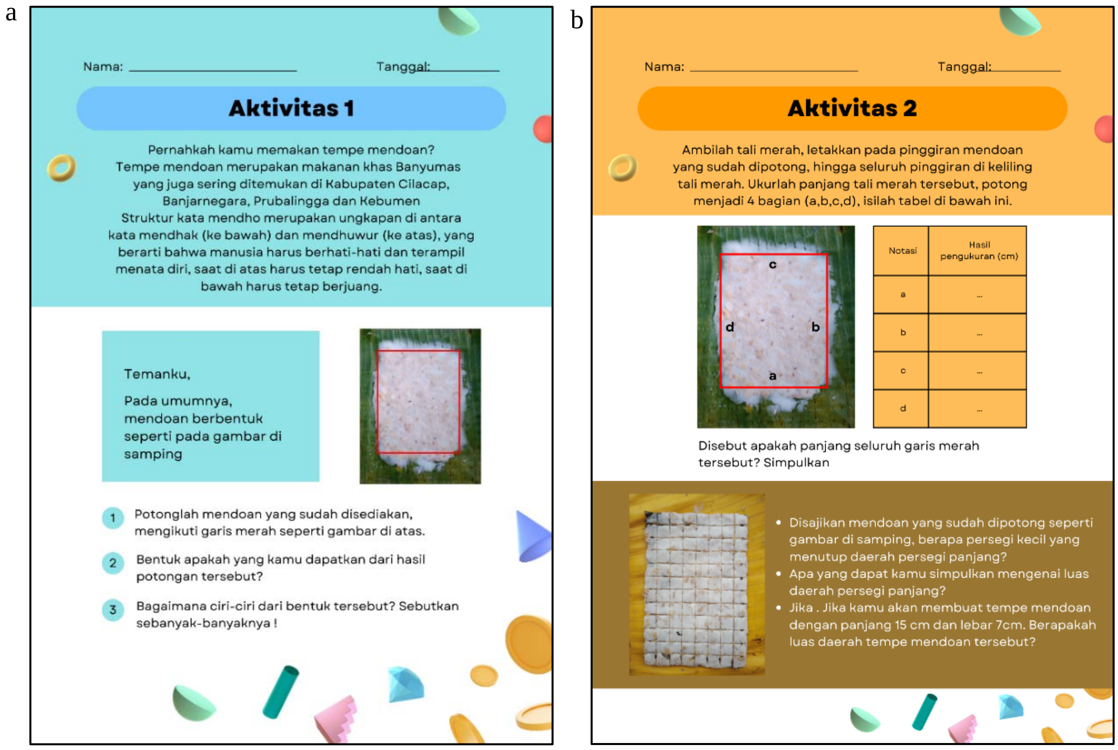

Figure 1. (a) Student Worksheet Activity 1; (b) Student Worksheet Activity 2.

3.2. Activity 2: Understanding the surface area of a rectangle through a unit square

Activity 2 is a "model of (referential)" from the level of development model (Gravemeijer, 1994). Intertwinement characteristics do not introduce or teach concepts in mathematics as a separate part. Psychologically, things that are related will be easier to understand and recall from long-term memory than things that are separated without being related to each other. The concept obtained from activity 1 is in the form of rectangular characteristics related to the re-construction of the concept of the perimeter and area of a rectangle in activity 2. Students carry out the activity of measuring the rope that surrounds a rectangle to find the concept of circumference. Students also carry out the activity of calculating unit squares that cover a rectangular area so that students can find the concept of the area of a rectangle. Figure 1 (b) presents the student worksheet activity 2.

3.3. Activity 3: Understand the shape of a right triangle

Activity 3 is a "model for (general)" from the level of development model (Gravemeijer, 1994). The construction of the concept of the area of a triangle is obtained through previous knowledge, which is the result of the model in student worksheet activity 2. Students carry out the activity of cutting the diagonal of a rectangle so as to produce two congruent right triangles. A right triangle is half of a rectangle. When doing the activity, the teacher monitors the way and the results of the students' cuts so that they can form a right triangle. Students have no difficulty in constructing this concept. Student worksheet activity 3 is presented in Figure 2 (a) below. The results of the for model from activity 3 in the form of the concept of the area of a triangle, will be used as initial knowledge to complete activity 4.

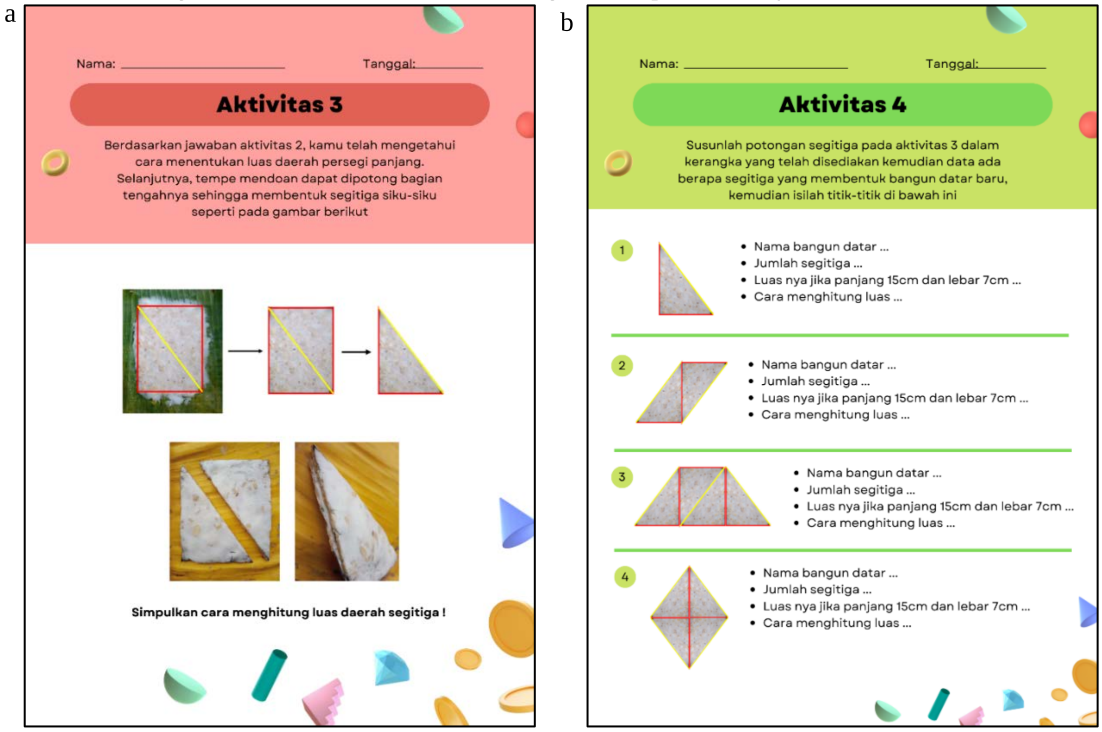

Figure 2. (a) Student Worksheet Activity 3; (b) Student Worksheet Activity 4.

3.4. Activity 4: Understand the formula for the area of a two dimension area

Activity 4 is a "formal" from the level of development model (Gravemeijer, 1994). Students construct formal concepts from the area of a triangle, parallelogram, trapezoid and rhombus. Students arrange *tempe mendoan* pieces in the form of right triangles to be attached to a two-dimensional framework. Students construct formulas for two-dimensional shapes through prior knowledge, namely from the area of a right triangle. For example, in a parallelogram, it can be composed of two right triangles. After completing the activity, students write down the results on the student worksheet so that a formal formula is found. Figure 2 (b) presents student worksheet activity 4. Figure 3 & 4 presents students' answers from the results of the limited trial.

There are two types of answers from students. Figure 3 presents the answers in tabular form and Figure 4 presents in the form of descriptions. Students have no difficulty in finding the formula for the area of a two-dimensional area. When asked the question of the area of a two-dimensional area if the size is known, students can answer correctly. However, students allegedly only memorized formulas that had been obtained previously because they did not write down the steps in finding the concept of a two-dimensional area. For example, in constructing the area of a parallelogram, student A writes $L = axt$. Student A does not write that the area of a parallelogram is obtained by adding up the two areas of a right triangle or twice the area of a right triangle. The same thing happened to student B. Student B immediately calculated the area of the parallelogram without writing down the formula.

The finding of this study is that the HLT that is compiled can facilitate students in rediscovering the concept of two-dimensional area. It's just that grade VII students may already know the formula for the area of a two-dimensional area so it is suspected that students memorize the formula. Further research is expected to complement HLT so as to produce LIT that can be used by students. Experimental subjects can be selected based on initial abilities. This is because, from previous research student achievement in the category of early middle mathematics ability did not provide a significant difference between PMRI and conventional learning. The same phenomenon was also shown by students in the category of early mathematical ability (Saleh et al., 2018).

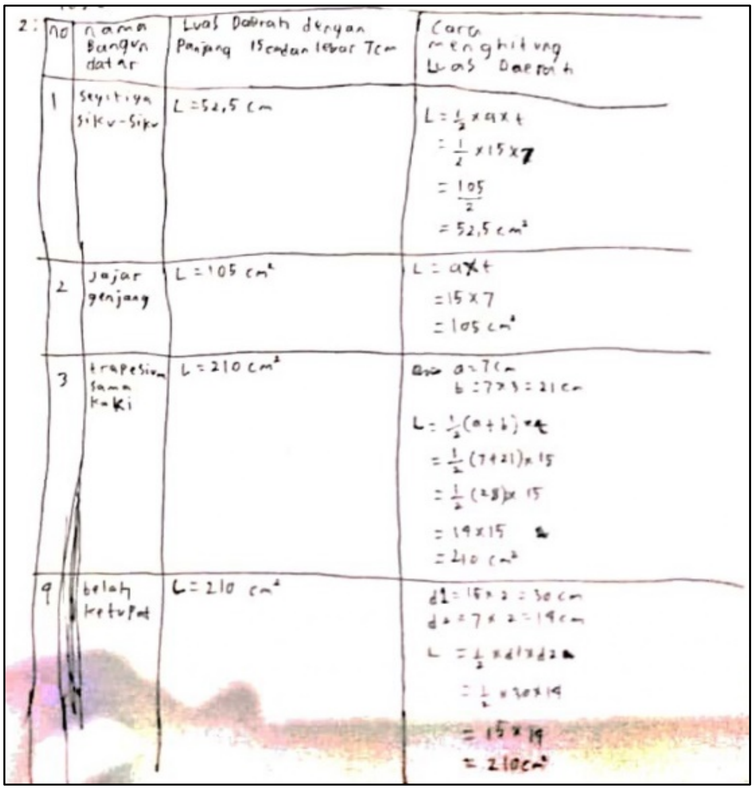

Figure 3. Student A's Answer

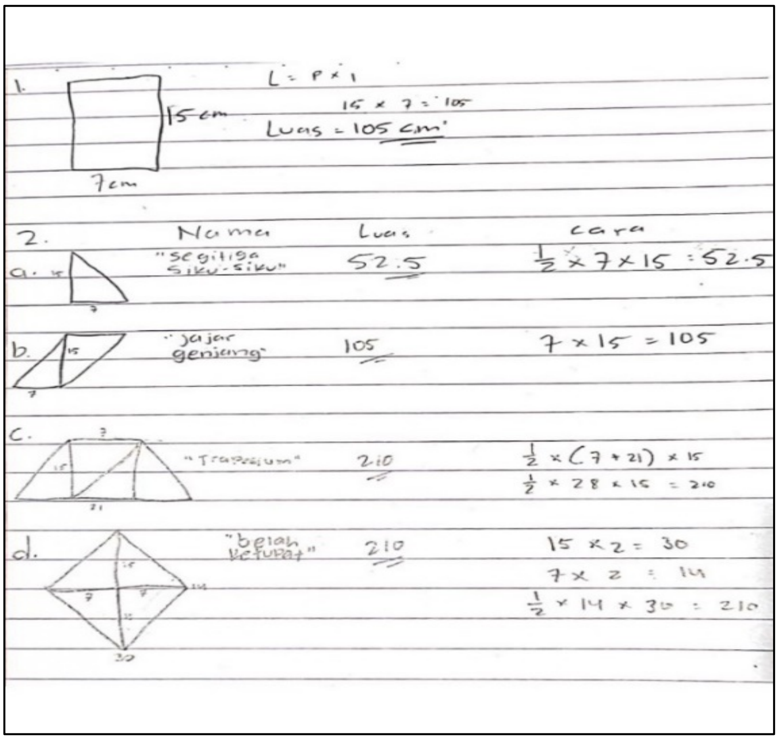

Figure 4. Student B's Answer

4. Conclusion

The preparation of HLT in this study was based on the principles and characteristics of PMRI which was adapted from the principles and characteristics of RME. HLT contains three main components, learning path, learning activities and learning conjecture. The three components of the HLT are divided into four levels of model development (Gravemeijer, 1994). There are four activities, each of which represents a development model from the situational level, model of, model for and formal. At the situational level, a realistic context is used in the form of a traditional Banyumas food, *tempe mendoan*. It can also enrich students' insight into a variety of traditional foods in Indonesia. Based on the results of the limited trial, it was concluded that students could construct formal knowledge about the area of a two-dimensional area. However, further research needs to be done that can experiment with HLT more broadly so that LIT is found. This is also supported by previous research on HLT (Wijaya et al., 2021; Ivars et al., 2018;Rezky & Wijaya, 2018; Ulfa & Wijaya, 2019).

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