Designing Hypothetical Learning Trajectory for Rotation Using Realistic Mathematics Education and Ethnomathematics

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Abstract.
This study aims to develop a learning trajectory to help students understand the rotation material and be motivated to learn. This study uses the context of the tedhak siten tradition which is used as a learning resource. The method used is design research with three main activities: preliminary design, design of the experiment (pilot experiment and teaching experiment), and retrospective analysis. This research involved class IX students of SMP Negeri 6 Semarang who carried out activities according to the Realistic Mathematics Education (RME) approach. The learning trajectory with the context of the tedhak siten tradition on rotation material consists of 3 activities, namely: 1) observing the traditional tedhak siten videos to find the characteristics of rotation, 2) finding formulas and drawing shadows of the results of rotation, and 3) solving contextual problems related to rotation. This article presents the initial stages of design research, namely preliminary design to provide detailed explanations at an early stage and ready to be tested at the design of the experiment stage.

Keywords: RME, etnomathematics, rotation.

1. Introduction

Transformation material is one of the important materials in mathematics that must be learned. Transformation consists of reflection, translation, rotation, and dilation [1]. In everyday life, learning transformation will be very useful in the field of design, for example batik design [2]. In addition, the benefits of studying transformations according to [3] are building spatial abilities, geometric reasoning abilities, and strengthening mathematical proofs..

Among the many benefits, the reality is that transformation is still material that is difficult for students to understand [4]. Students' difficulties in transforming material include 1) identifying the position of the image, 2) solving problems related to the displacement of objects, 3) identifying problems related to lines that are rotated through the center of rotation [5]. Students have difficulty understanding the concept of transformation [6]. Lots of memorizing formulas makes students forget [7]. Students have difficulty choosing the right formula to solve the problem correctly [8]. The large variety of questions and unsustainable learning also causes students to experience difficulties when working on transformation questions [9].

Factors causing students' difficulties in learning transformation include the lack of use of learning media which can make it easier for students to understand transformation material while at the same time attracting students' attention to be more interested in learning [10]. The teacher does not implement student-centered learning so that students only catch material that students understand shallow [11]. Students are less directly involved in learning [9]. Lack of use of information technology to provide clear visuals so that students can absorb the material optimally [5].

In order for learning to get maximum learning outcomes, a mathematics learning design is needed that is linked to everyday life so that students can understand the use of mathematics directly [12,13]. One model of learning mathematics based on reality and the environment is the Realistic Mathematics Education (RME) model.

Realistic Mathematics Education (RME) is an approach to learning mathematics that starts from things that are real for students, connected to reality, close to students, and relevant to people's lives [14]. RME can make learning more meaningful, enjoyable, develop students' concepts in the material being studied, and improve the quality of learning processes and outcomes [15,16]. The RME learning principles according to [16] are as follows: 1) activity-based; 2) based on reality; 3) solving problems in stages; 4) connectedness; and 5) social interaction. One of the characteristics of RME is using context [17].

Several contexts of local wisdom that have been used in learning are the RME model in tube material with the context of traditional food [13], cone material with the context of tradition in an area [18], reflection material with the context of historic buildings [19], and building materials in the context of traditional events [20]. The context used in this research is the context of the tedhak siten tradition to study transformation because many concepts of transformation can be explored from the tedhak siten tradition. In addition, using this context can foster a love for local wisdom in the area.

Based on the problems described above, this research was conducted to design rotational learning using the traditional tedhak siten context to improve conceptual understanding, motivate students, and create meaningful learning.

2. Method

The method used in this research is design research to develop the instruments used in learning. The subjects involved in this study were class IX students of SMP Negeri 6 Semarang. Data collection was carried out from August to September 2023 through several activities such as observation, video recording, collecting student worksheets, giving pre-tests and post-tests, and interviews. The data that has been collected is used to see the learning process that students go through. In design research, it consists of 3 main stages, namely 1) preliminary design, there are several activities in this stage such as literature review, reviewing student abilities, and formulating a Hypothetical Learning Trajectory (HLT), 2) design of the experiment there are two stages, namely experimental pilot (HLT testing in small groups) and teaching experiments (testing to actual classes by first revising the data from the pilot experiment), 3) retrospective analysis, all data obtained is analyzed based on HLT (comparing HLT with actual learning) to develop designs for further activities . In this article, the researcher only explains the first stage, namely preliminary design, such as examining the basic competencies possessed and needed by students and formulating student learning trajectories in the context of site ten in rotational material.

3. Result and Discussion

In the first stage of design research, there are several activities that must be carried out such as reviewing the literature, examining students' initial abilities, and preparing a Hypothetical Learning Trajectory (HLT). A literature review was conducted to collect information about transformation material through books, then a literature review was conducted on RME and research design. This is done to formulate an initial strategy in designing learning. Furthermore, what is done is to examine the ability of students to determine the ability of student prerequisites. What was done above was used to formulate a dynamic Hypothetical Learning Trajectory (HLT) that could be revised during teaching experiments. In this article, it is explained about the study of students' initial abilities and the HLT formula as follows:

3.1. Examining the Basic Competencies that Students Have and Need in Rotation Material

In studying rotational material, there are several basic competencies that students in class III already have, namely: 1) analyzing how to measure angles with a protractor and 2) analyzing and determining the size of a rotating angle. Furthermore, in class VIII, namely: 1) determine the position of the point with respect to the reference point (0,0), 2) determine the position of the point with respect to the reference point (a,b), 3) determine the position of the point with respect to the x-axis, and 4) determine the position point on the y-axis.

3.2. Developing a Hypothetical Learning Trajectory

After the literature review activities and examining students' initial abilities, the next step is to formulate and develop HLT rotation material in the context of the tedhak siten tradition. This HLT contains a series of learning processes consisting of 3 activities that are useful for increasing students' understanding of the material, motivating students, and creating meaningful learning.

The learning objective in the first activity is to find the rotation properties through observing video contexts. This activity begins with observing the context video. Then in groups, students look for objects in the tedhak siten tradition that experience rotation. In this case, students are expected not only to be able to describe objects that experience rotation but also to discover the properties of rotation. In addition to using student worksheets, students are facilitated by learning media in the form of supporting applications and GeoGebra software to make it easier for students to work on student worksheets. The teacher's role here is to ask questions to students in order to help discover the characteristics of rotation. In the student worksheet, there are several questions that must be done by students. At the end of the activity, students conclude the properties of rotation.

Figure 1. Tedhak siten tradition
Source: https://i.ytimg.com/vi/I1BDYO-haE0/maxresdefault.jpg

In activity 1 the assumptions of students' thinking are presented in table 1.

Table 1. Conjecture students' thinking in activity 1.

No.	Activity	Conjecture
1	Observing the video in the context of the tedhak siten tradition.	Students can identify objects that experience rotation Students can draw objects that experience rotation
2	Doing activity 1	Students can discover the properties of rotation

Reflecting on activity 1, students may have difficulty determining objects that experience rotation in contextual videos because they have never gotten them before. However, students will easily draw objects that experience rotation and discover the properties of rotation.

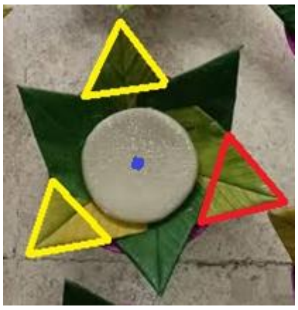

Figure 2. Jadah cake

Source: https://images.app.goo.gl/KbrjMxKZpT9Qv3NLA

The learning objectives in activity 2 are to find the rotation formula and paint a picture of the results of the rotation. Activity 2 begins by observing a context video related to jadah. Then in groups, students look for the rotation formula (clockwise or counterclockwise). In this case, students are expected not only to be able to find the rotation formula but also to be able to paint the image of the rotation result. In addition to using student worksheets, students are also facilitated with learning media in the form of supporting applications and GeoGebra software to make it easier for students to work on student worksheets. The teacher's role here is to ask questions to students when operating Geogebra in order to find the rotation formula and how to paint the shadow of the rotation result. On the student worksheet there are several questions that must be done by students. At the end of the activity, students conclude the rotation formula along with how to paint the image of the rotation result.

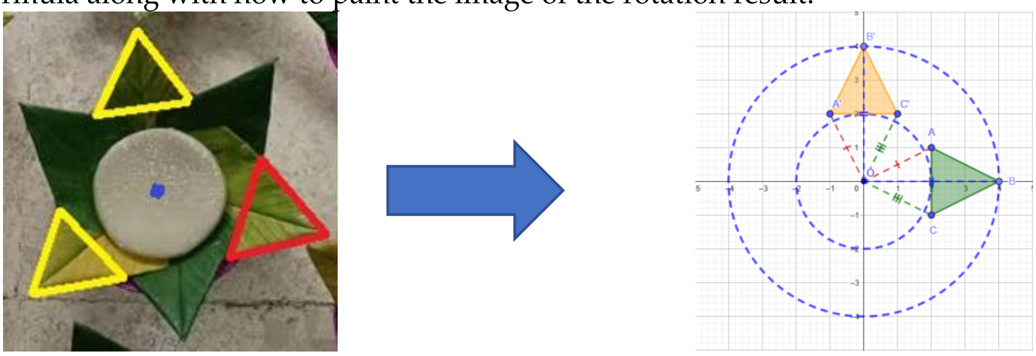

Figure 3. Find the formula and paint the shadow resulting from the rotation

Source: https://images.app.goo.gl/KbrjMxKZpT9Qv3NLA

In activity 2 the assumptions of students' thinking are presented in table 2.

Table 2. Conjecture students' thinking in activity 2.

No.	Activity	Conjecture
1	Observing the rotation of leaves on jadah	Students can operate geogebra Students can find the shadow pattern resulting from the rotation
2	Doing activity 2	Students can determine the rotation formula and draw shadows of the rotation results

The reflection of this activity is that students may be able to find patterns of rotation results. However, students will experience difficulties in painting the rotational shadows.

The purpose of learning in activity 3 is to solve contextual problems related to rotation. Students are given several questions related to rotation that have been studied before. The teacher's role here is to monitor and provide direction to all students.

In activity 3 the assumptions of students' thinking are presented in table 3.

Table 3. Conjecture students' thinking in activity 3.

No.	Activity	Conjecture
1	Doing activity 3	Students are able to solve problems related to rotation

Based on the results that have been described, the initial stage of design research is to prepare experiments through several activities, namely carrying out literature reviews, examining the competencies possessed and needed by students, and formulating HLT. The activities carried out in preparing for the experimental stage are formulating an initial strategy in designing learning. This is in accordance with [21] which suggests that conducting a literature review can determine initial learning strategies and can be used to formulate HLT. The initial design of this lesson is needed to make it easier for students to understand the rotation material well from the informal to the formal stage. The context used in RME-based learning is a learning resource that can assist students in learning rotations. This is in accordance with [21] who argued that context can support material understanding. The results of other studies also state that learning with the right context can motivate, facilitate understanding, and create meaningful learning [15].

4. Conclusion

This research produced a rotational Hypothetical Learning Trajectory using the context of the tedhak siten tradition to facilitate students' understanding of the rotation material, motivate students, and create meaningful learning. The HLT formulated in the first phase of design research can be used in the next stage, namely experimental design. This rotation HLT consists of 3 activities, namely: 1) observing the video of the siten tedhak tradition to find the properties of rotation, 2) finding the formula and painting the shadow of the rotation result, and 3) solving contextual problems related to rotation.

In designing learning in the first stage of research design, researchers must equip students with situations as real as possible to explore and obtain informal information which is then brought to the formal stage using modeling. In addition, the instruments used must also support such as student worksheets which can make it easier for students to understand the material and the teacher is in charge of guiding students if students make mistakes in the learning process. Reflections on each activity in HLT also need to be explained in order to perfect the designed instrument and anticipate mistakes and students' difficulties in carrying out activities.

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