

Triggering fourth graders' informal knowledge of isometric transformation geometry through the exploration of Malay cloth motif

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Abstract. Existing study revealed that the children have dynamics spatial sense on objects. One of important mathematics topics that can be related to the sense-triggering process is the isometric transformation geometry including reflection, translation, and rotation. This topic is introduced to the fourth and the fifth graders of elementary school. However, learning process in school tends to lack concern on this students' readily-triggered ability. There is also insufficient number of hands-on activities experienced by the students. It is poor since the hands-on activities can facilitate students' informal knowledge of isometric transformation geometry. Therefore, this two cycled design research aims to counter such situation. It was conducted at State Elementary School 001 of Toapaya, Kabupaten Bintan, Kepulauan Riau by using RME approach. The subject of the study was the fourth graders. Malay cloth motif was used as the context of the study through the exploration activities. The results indicated that the activities could trigger students' informal knowledge of: reflection, translation, rotation, constant factors, and transformation composition.

Keywords: *isometric geometry transformation, transformation composition*

1 Introduction

One important concept in geometry is transformation, which can be expressed as mapping an object of geometry on a plane from one position to another with certain rules (Hardiyanti, 2015). There are two kinds of known transformation geometry, namely the isometric and non-isometric transformation geometry. The geometry of isometric transformation is a transformation that retains the shape and size of the transformed object (Talbert in Mashingaidze, 2012). Reflection (reflection), translation (shift), and rotation (rotation) are three examples of isometric transformation forms. While dilatation (enlargement-reduction) belongs to non-isometric transformation because it only maintains the shape. This study has a focus on isometric transformation geometry.

Transformation is a crucial knowledge in geometry. This knowledge is useful for building spatial abilities, geometric reasoning abilities, and strengthening mathematical proof (Edward in Albab et al., 2014). Some of these abilities are proven to support achievement in mathematics, especially the reasoning of transformation geometry.

The reasoning of transformation geometry is the process of thinking, understanding, and making decisions based on logical processes related to the transformation geometry. Reasoning in transformation geometry can be graphical/visual reasoning and algebraic one according to the nature of transformation geometry which can be approached by two methods: graphically and algebraically (Mashingaidze, 2012).

Given the importance of the concept of transformation in geometry, students as individuals are important targets for the development of this geometric capability. NCTM (2000) states that learning of transformation geometry should be given from kindergarten to high school level so that students are able to use the ability of transformation geometry to analyse mathematical situations.

There are several opinions that support the statement. Hollebrands (2003) argues that the learning of transformational geometry can give students the opportunity to think about other important mathematical concepts such as symmetry, congruence, function, etc. and realize that geometric transformation involves multiple disciplines and allows for reasoning to flourish. In line with that opinion, the transformation of isometric geometry (especially translation and rotation) can be the foundation for students' geometric understanding because of their dynamic nature, thus allowing students to link this concept with other geometric concepts such as congruence and equivalence (Panorkou et al 2015). The geometry of transformation and some important related concepts can help students analyse mathematical situations and develop their reasoning.

Judging from the curriculum applied in Indonesia, KTSP and Curriculum 2013, isometric transformation geometry was introduced in elementary school bench from class IV and class V through the concept of symmetry and then followed by reflection (reflection). The usual practice is that teachers directly introduce the concept of reflection at the formal level. That teachers present it by means of knowledge transfer, and students are directly located to illustrate the process of reflection by using paper in print.

There are some points that are in the spotlight in the process of learning this transformation geometry. First, students are not there to know the transformation informally first through the exploration of student's daily phenomena. There are so many phenomena in life that can lead students to

the early concept of geometric transformation. Unfortunately, this section is actually passed by the teacher. As a result, learning becomes less meaningful and students find it difficult to build their understanding. Second, fewer students are given the opportunity to explore the real/concrete objects they can move. Most students are only served with static objects in the form of images on grid paper. Learning is limited to passive observations of static images on paper that ultimately limit the understanding of the geometry of the overarching representation of object shape (Panorkou, 2015). This has an impact on the emergence of misconceptions as students decide that a triangle that is essentially not horizontal is not a triangle.

Third, there is no discussion of important concepts, such as whether it is the axis of reflection, its function in transformation, reference point, congruence, distance, and so forth. Students are placed to accept all the important concepts as a ready-made / ready-to-use item without any exploration of its essence. Consequently, students cannot see the interrelationships between these important concepts. Many students also fail to draw a reflection of the object of reflection. Fourth, translation and rotation are only introduced at a glance without any further search. Students are asked to explore independently two concepts that should be a priority for discussion regarding the understanding of geometric transformation. This is directly related to the misconceptions that appear in the second case. Students cannot see that the triangle is not the horizontal base is the same triangle with the horizontal base but has undergone rotation (rotation).

Research shows that children have a dynamic spatial 'sense' of things, they can 'see' an object by its changing characteristics (Lehrer, Jenkins, and Osama in Panorkou, 2015). Unfortunately, this knowledge tends to be unknown to teachers, especially elementary school Mathematics teachers. Presenting the teaching of the transformation of isometric geometry without accommodating this knowledge will make students unable to utilize their potential to support learning.

To understand the concept of Mathematics, it is necessary to engage concrete learning experiences using real objects (Bentley and Malven in Mashingaidze, 2012). Not only that, something that can be imagined by the learners related to the concept of isometric geometry transformation can be utilized in the learning process.

Based on this issue, an innovative solution is needed to reduce the practice of learning geometry of isometric transformation in elementary schools that are still weak. Gravemeijer (2010) suggests that learning will work better if students are taught from an informal level where they recognize it in

everyday life. Thus, it takes a daily context that can accommodate students' early knowledge to begin learning geometric transformation.

Kepulauan Riau is a province with a strong Malay culture and have a variety of local cultural products that can be used in a learning context. In this research, Malay cloth motif became a learning context because it has a variety of patterns that are rich in the concept of geometry and geometry transformation. Through the exploration activities around the motif, it is hoped that the children are triggered to expose their informal knowledge of isometric transformation geometry through the reasoning activity. Therefore, the question to this study is: what kind of activities that can trigger fourth graders' informal knowledge of isometric transformation geometry by the use of *malay* cloth motif context?

2. Methodology

This research is conducted in order to find Local Instruction Theory which emphasizes on the development of reasoning of transformation of the isometric geometry of elementary school students, especially class IV. To construct such a local theory, some appropriate activities for the reasoning to be emerged are set. It is hoped that some informal knowledge of students on isometric transformation geometry are exposed. Therefore, design research is used as the research approach. This study is conducted by using two cycles of design research namely preliminary teaching experiment and teaching experiment. In both teaching cycles, knowledge transfer is transformed into meaningful teaching (Sembiring, Hoogland, & Dolk, 2010). Thus, the learning model used is Indonesian Realistic Mathematics Education (Indonesian RME) with a series of learning activities designed using Malay cloth motif. Setting up learning activities based on RME was categorized good (Sari in Sari, 2017).

Subjects in this study were the fourth graders of the State Elementary School 001 Kabupaten Bintan, Kepulauan Riau. A total of 6 students of grade IV from class A made the subject of the first cycle research. Meanwhile, all students of grade IV from class B were the subjects of research on the second cycle.

This paper presents the acquisition of the second cycle through testing the hypothetical learning trajectory. It includes the exposure to learning objectives, mathematical aspects, students' mathematical activities, and learning paths which later became the foundation of Local Instruction Theory on the learning of isometric transformation geometry. This theory supports the development of students' reasoning of isometric transformation geometry through motif exploration of *Malay* cloth from Kepulauan Riau.

Data collection techniques used were interviews, observations, and tests. Against the data obtained, retrospective analysis with descriptive analysis technique and triangulation of data was conducted. It aims to compare the hypothetical learning trajectory with the real learning path.

3. Results and Discussion

This section discusses the results of design research of second cycle (teaching experiment). There are five activities with two learning contexts. Each activity contains learning objectives, mathematical activities, and conjecture of student thinking which then provide information about the student's learning path.

The following exposure is a series of activities that illustrate the student's learning path on the topic of isometric transformation geometry with the Malay cloth motif context to develop the reasoning. Through reasoning activities, the informal knowledge that students have about the transformation of isometric geometry could be emerged and identified.

Activity 1

The first activity is about recognizing motif and variation of a motif patterns of Malay cloth. The purpose of learning in the first activity is to reason visually about the concept of reflection, translation, and rotation and their characters through observation on variations of motif patterns. Through reasoning activities, it is expected that students can express their informal knowledge. The context used is a Malay cloth gallery that shows three different pattern variations composed of a single motif of *itik pulang petang*. The variations are arranged with translation, reflection, and rotation techniques.

Firstly, all three variations were displayed to all students. They were asked to report their observations in the form of differences in the three pattern variations. Notice figure 1 below.

In this activity, students showed some of their informal knowledge such as unit repetition. Students were of the opinion that variation of the pattern was formed by repeating motif of *itik pulang petang* by executing transformation technique. This indicates that the student understands that the transformation does not change the size of the subject being replicated.



Figure 1. Students reasoning on the difference of variation of patterns

Some informal terms conveyed by students representing translations were 'arranged in a row', 'slided/shifted', and 'arranged in March'. While the informal terms that describe reflections were 'made opposite', 'opposite direction', and 'pairing'. Rotation was represented by the phrase 'rotated', 'made circular', 'rounded', and 'around'. Some of the things that cause this visual reasoning to occur are that the arrangement setting and sequencing of the pattern variation into order that make the students aware of the differences in the single motif arrangement in each variation so as to entice the conversation related to unit repetition and transformations at the informal level.

Activity 2

Activity two is a continuation of activity one. This activity is called "with a piece of motif, let's think about the drawing technique". Students were asked to remember the arrangement of motif in variations of patterns 1, 2, and 3. Furthermore, the display of variation of the pattern was stored. The student activity sheets were distributed to each student. The sheets contained the questions of how the artisan made variations in patterns from the motif of *itik pulang petang*. In this case, students were asked to predict the technique of making pattern variations.

The purpose of the second activity is to review the students' visual reasoning on translational transformation, reflection, and rotation techniques in the making of variations using a single motif. To support students making predictions and reasoning, they were given one piece of *itik pulang petang* motif. They were asked to give answers to the student activity sheet.

Some of the responses given by the students included that the variation of pattern 1 was formed by shifting a piece of motif continuously in a certain direction and repeatedly several lines. There has been no awareness among students regarding constant factor in shifting. In the meantime, the question of pattern 2 variation was responded more tactfully. In general, students explored a piece of the motif by rotating it to its midpoint; reversed and

shifted. They did it to force the motif to be opposite. The student decided that in order to make a pair of motif facing each other, one of the drawings was made by reversing the motive. Tracing was a technique that students did in motif propagation to build variations.

Meanwhile, the 3rd pattern variation was formed by rotating a piece of the motif. However, there has been no awareness of the rotary axis or rotation reference point in the process. Activity was continued with activity 3 with the same context.

Activity 3

The third activity is a follow-up of the second activity. Students drew a variety of pattern 1, 2, and 3 from a piece of motif provided with grid paper media, pins, threads, and styrofoam, as well as drawing tools such as pens and markers. Through the activity, it is expected that students can use the actual understanding of their transformation geometry in the context of drawing pattern variations from the motif of *itik pulang petang*. When describing the first variation of the pattern that contains the translational transformation, most of the students brought up the idea of the distance that is always maintained between the motif images being reproduced using a translation (see figure 2). This is similar to the activity of drawing the third pattern variation with the rotation technique. Students were aware of a strategy that must be done to keep the distance of the motif drawn in a constant circular transformation. However, so far students only estimated the location of the motif within the circular movement.



Figure 2. Student drawing pattern by translating motif

While pins and threads were used as a tool to make a good turnaround (see Figure 3). From both activities, it can be concluded that the students develop the concept of constant factor in translation and rotation. In translation, the constant factor is the fixed distance to produce the desired pattern image. Meanwhile, the constant factor in rotation is the fixed distance and the fixed angle of rotation.



Figure 3. Students rotating motif to complete pattern

Furthermore, to draw a variation of the second pattern, students realized that in order to make the motifs of each other, the motif is reversed and plagiarized so that it is symmetric to the previous motif image. This shows that students understand the nature of an object that is transformed using reflection technique. It will be different in its orientation but symmetrical.

Activity 4

The fourth activity uses the context of the motif above the printed grid medium. Activity take the form of class discussion. There is a motif of *itik pulang petang* in a triangle. The motif will be used for students' reasoning regarding the location or position of motif resulted by undertaking transformations on it. For that, students require a printed grid media and pins to put motifs on the media. The purpose of this activity is that students can recognize transformations as displacements of transformed starting points, line and point of reference, orientation, a constant factor, and transformation composition.

The first case put the motif in a triangle in the lower left corner of the printed grid medium. The triangle corner point was marked with different colored pins. Then, another pin was located in another area in printed grid media. The task of the student was to find two other point locations so that transformation that dissipates the motif could be defined the.

In general, students could reason in finding two other point locations so that the case was translational. Other students might even indicate that such displacement might occur as more than one shift was made.

Another case was that students were asked to define the type of transformation such that the motif position in the initial triangle was reversed (see figure 4). Some students could find the location of other points so that they could define their transformation appropriately. From this activity, it can be concluded that students have understood the lines and

points of reference, orientation, constant factor, and transformation composition.



Figure 4. Student determining the location of other points and defining the transformation executed to move the initial motif

Activity 5

Activity 5 is a top activity where students were conditioned to explore in the form of moving motifs in triangles containing cases of translation, reflection, and rotation on the printed grid media. Each group of students was given a printed grid media and stationery set to conduct exploration. Figure 5 below is the work of one group.

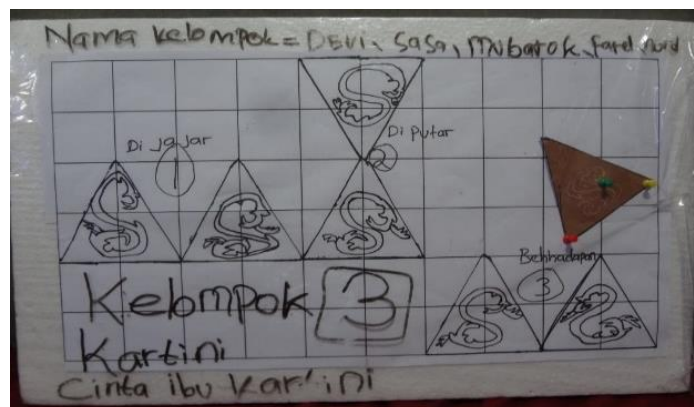


Figure 5. Group's work displaying three transformation of motif within triangle by the use of grid

The work shows that students have understood translations, rotations, and reflection as forms of technique to move the initial object to another position on the printed grid media. From these results students also described the understanding of the orientation of transformed objects, reference points, and isometric transformation geometry.

4. Conclusion

The results show that the five activities can facilitate the development of a good learning path in order to develop the reasoning of isometric transformation geometry. Setting of activities 1-3 facilitates a continuous student's reasoning starting from recognizing transformation through observation and then exploration of transformation. Activities 4 and 5 facilitate students to develop early knowledge of reference points, constant factors, and transformation compositions. There are several arguments in support of this conclusion. First, learning is designed using the daily context of Malay cloth motif of Riau Islands. The context used is dynamic and allows students to have hands-on activity by moving objects freely. Finally, setting up activity by considering the development of reasoning becomes the main basis of the success of this learning.

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