LEARNING LINE SYMMETRY THROUGH BATIK EXPLORATION

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Abstract

The concept of symmetry is essential not only in geometry but also in human life. Therefore, students need to have a good basic understanding of the concept of symmetry. However, many studies found that students have difficulties in understanding it. By considering those difficulties, there is a need of developing a learning sequence which can support students to have a better understanding of the concept of symmetry particularly line symmetry. Hence, this study aims at supporting students to learn the concept of line symmetry by exploring the characteristics of Batik, Indonesian traditional patterns. This study uses Batik as the context because the patterns are not only familiar for students but also contain the concept of line symmetry. This study uses design research as the research approach as this study also wants to contribute an innovative instructional design. The teaching experiment is designed by implementing Realistic Mathematics Education (RME) and conducted by orienting the designed hypothetical learning trajectory. Five fifth-grade students of Laboratory Elementary School of Surabaya are involved in this study. Then, the data are collected from recording the teaching experiments, students' written works, and students' interview. The collected data are analyzed by confronting the hypothetical learning trajectory to the actual learning trajectory. The analysis result shows supporting evidence that exploring Batik pattern can support the students to emerge with the concept of line symmetry.

Keywords: Line symmetry, Batik, Realistic Mathematics Education (RME)

INTRODUCTION

This study is mainly focus on the concept of symmetry. Symmetry is chosen as the concept because it is not only essential in geometry but also in human life. Related to mathematics, *Principles and Standards for School Mathematics* (NCTM (2001), cited in Panaoura, et al., 2009) pointed out the importance of the concept of symmetry in learning geometry. By considering the importance of symmetry, Knuchel (2004) stated that it is very crucial for students in elementary school to have a good basic understanding of the concept of symmetry so that they can realize how symmetry is applied in their life. However, not every student is aware of this (Knuchel, 2004). They even have difficulties in understanding the concept of symmetry. The study of Roberts (2008) revealed the fact that students often have a misunderstanding that diagonal of two-dimensional shapes could always be referred as the axes of symmetry.

Consequently, they perceive a parallelogram as a symmetric object. The students have a tendency to define the axes of symmetry as a line which divides the shape into two congruent parts without considering the requirement that the two parts of the whole are each other's mirror images (Leikin, 2000). Since the students seem to have difficulties in learning the concept of line symmetry, many researchers tried to study

this issue. Most of the studies used dynamic geometry software as a medium of learning the concept of symmetry rather than other media (Gibbon, 2001; Hoyles & Healy, 1997; Knuchel, 2004; Mackrell, 2002; Seidel, 1998). However, it should be taken into account that employing dynamic geometry software as a learning media needs adequate supporting facilities such as computers and teacher's ability in utilizing the software. By considering those issues, using dynamic geometry software is not feasible to be applied in Indonesia for several reasons. Laksmiwati and Mahmudi (2012) stated that not every school in Indonesia provides adequate computer facilities to the students and not every mathematics teacher is able to operate the geometry software. Therefore, there should be other alternative ways to support Indonesian students to learn mathematics. Based on van Den Heuvel-Panhuizen (2003), everyday application problems can be used as a milestone for students to start learning the mathematical concept. One of everyday application problems which can be perceived as a meaningful context to introduce the concept of symmetry is Batik, Indonesian traditional pattern. Batik is very potential to be used to learn symmetry as the process of making Batik involves the concept of symmetry (Haake, 1989). Yusuf & Yullys (2011) also stated that mathematics and culture could be combined to learn mathematics concept. This combination can be perceived as an innovation of educational practice mathematics as there is no study which employs Batik as a medium for learning the concept of symmetry.

RESEARCH QUESTION

The research question of this study is :

"*How can Batik, Indonesian traditional patterns support students' understanding of the concept of line symmetry*?"

RESEARCH AIM

This study aims at supporting students to learn the concept of line symmetry by exploring the characteristics of Batik, Indonesian traditional patterns.

THEORETICAL FRAMEWORK

The instructional activities of this study are designed by using Realistic Mathematics Education (RME) as the main theory. It follows the five following tenets of RME (Treffers, 1987),

1. The use of context
2. Using models and symbol for progressive mathematization
3. Using students' own construction
4. Interactivity
5. Intertwinement

RESEARCH METHOD

The research method of this study is design research. It is chosen because of several reasons. First, the main purpose of design research is in line with the purpose of this study which aims at creating educational innovation for improving educational practices. Second, design research perceives designing instructional sequences as the essential part of the research and it aims at developing theories of how the design supports the learning of students. Hence, this methodology allows the researchers to focus on students' understanding and its process in the educational setting activities so that they can study both aspects as integrated and meaningful phenomena (van den Akker et al., 2006).

The design experiment in this study will be conducted in three phases which are (1) Preparing for the experiment; (2) The design experiment; (3) The retrospective analysis. In the first phase, the researcher studies relevant literature to get more insight in designing the learning activities and the Hypothetical Learning Trajectory (HLT), conducting classroom observation, teacher interview and pre-test. The design experiment of this study consists of three cycles of teaching experiment. However, this paper only presents the first cycle of the study and discusses mainly an activity which focuses on the learning process of line symmetry.

The data is collected by recording the teaching experiment, collecting students' written works and interviewing students. Then, the researcher analyzes the data by confirming the actual learning trajectory with the HLT. In the retrospective analysis, the researcher confronts the actual learning trajectory with the HLT and discusses whether they match or not.

RESULT AND DISCUSSION

This section will discuss the learning process of line symmetry of the first cycle and its retrospective analysis. The first cycle of this study involves five 5th grade students of Laboratory Elementary School of Surabaya and the researcher as the teacher.

Pre-test

The pre-test has been conducted before the teaching experiment in order to know the prior knowledge of the students before getting involved in the teaching experiment. The result of the pre-test is described as follows:

1) The students are able to identify the symmetrical objects except a parallelogram. When they were asked to explain the reason, they said that a parallelogram could be divided into two same parts by drawing the diagonal. They assume the diagonal of the parallelogram as its axes of symmetry. These students' answers imply that the students perceive line symmetry as the symmetry which makes the object becomes two identical parts without considering that the two parts should reflect each other.
2) The students have a basic understanding of symmetry. When they were asked to give the reason in determining the symmetric objects, they answered because the objects have axes of symmetry. The answer shows that they already acknowledged the symmetric objects should have the axes of symmetry. Then, when they were asked to draw the axes of symmetry of the objects, they could draw it correctly. They are aware that the axes of symmetry must be in the middle of the objects and divide the object into two identical parts. However, as they perceive a parallelogram as a symmetric object, they also draw the diagonals of the parallelogram and perceive them as the axes of symmetry. In other words, the students seem to have difficulty in differentiating the diagonal and the axes of symmetry.

The Learning Activities

This paper focuses on an activity which concerns on supporting the students to learn the concept of line symmetry. The activity aims at supporting the students to be able to differentiate the patterns that have regularity (line symmetry) and the patterns that have no regularity. In this activity, the students get twelve batik patterns. They should sort the patterns into two rooms based on the regularity and give their reasoning of sorting. Based on the HLT, the students are expected to sort the patterns into two rooms

in which the first room consists of patterns with repeating motif (regularity) and the second room consists of patterns with random motif (no regularity).

Figure 1. The twelve batik patterns

In the beginning of the lesson, the students were oriented to the Batik context and asked about what they knew about Batik. They responded it by relating Batik with their uniform. They also acknowledged that Batik has various kinds of patterns such as flowers or animals. The following transcript shows that the students only use their sense of symmetry when they are trying to determine the regular Batik. This transcript is the discussion among the three students.

(Situation : a group of three students, one student was writing the discussion result on the worksheet, they were figuring out the patterns which have no regularity by observing the patterns on the worksheet.)

Adit : "*pattern B can be a pattern which has no regularity*."
Nito : "*yes, it can be*"
(*Adit was writing the discussion result of patterns which have no regularity*). *Then, they continue observing the next batik patterns.*
Nito : (*talking to Adit and referring to Batik pattern C*) "*C*"
Emir : (*talking to Adit and referring to Batik pattern E*) "*E*"
Nito : (*talking to Adit and referring to Batik pattern F*) "*F*"
Nito : (*talking to Adit and referring to Batik pattern J*) "*J*"
Emir : "*J is regular. It cannot be a pattern that has no regularity*."
Nito : "*It can be. Look*." (*pointing his pen to the pattern J*)
Emir :"*It cannot be*." (*making a finger gesture which shows a basic acknowledgement of line symmetry toward the batik pattern*)

The transcript shows that the students argue about pattern J. Nito thinks that J is the pattern which has no regularity. Nito may assume pattern J as the pattern which has no regularity because this pattern only consists of two same parts instead of many parts as D and H (four same parts) or G (16 same parts). Interestingly, Emir tries to convince their friends by using his finger and putting it on the pattern as it is the axes of

symmetry of the pattern. It implies that the students do have a sense of symmetry in which they aware that the regular pattern can be divided into several same parts. Their way in determining the regular patterns by using their sense of symmetry has not stated in the HLT. Therefore, related to this students' respond, the HLT needs to be revised.

In addition, there is a difference between the results of two groups in the class discussion, group 1 perceives H as a batik pattern which has no regularity. Meanwhile, group 2 perceives it as a regular batik pattern. The following is the transcript of the discussion.

Researcher : "*Adit's group perceives H as the pattern which has no regularity, but Shandi's group perceives it as a regular batik pattern. Why is it so*?"
Shandi (group 1) : (*pointing batik pattern H*) "*wait, don't you think that it will be the same if we fold it*? "
Arya (group 1) : "*It is symmetric*"
Nito (group 2) : (*agreeing with Shandi's answer and talking to Adit*) "*Yes Dit, it will be the same*, *it's symmetric*"
(*Other students start to realize that the Batik pattern H is symmetric*)
Shandi (group 1) : "*Oh yaa symmetric, I just realized it*"
Nito (group 2) : "*Yaa symmetric, why don't you say it from the beginning*?
Researcher : "*Why is it symmetric*?"
Shandi (group 1) : (*pointing batik pattern H*) "*It's symmetric because if we fold it, the pattern will be the same*"

The students start to realize that batik pattern H is symmetric because if it is folded, then the two folded parts will have the same pattern. This awareness shows that the provided batik patterns can support the students to emerge with the basic concept of symmetry. However, when the students were asked to explain their reason of classifying the batik patterns into two rooms, they did not understand how they should explain. As the result, they just wrote what they knew about regularity in the pattern as follows,

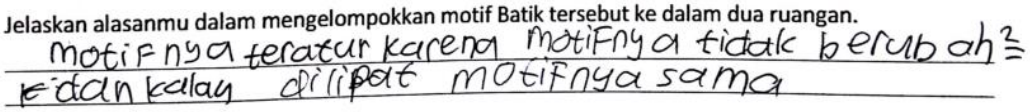

Figure 5.8. The Example of Students' Answers of The First Activity
Figure 3. The example of students' answers of in reasoning

Even though the answer on the figure 3 is relevant and shows the students' acknowledgement about regularity, but this answer does not answer the question. Based on the HLT, they should answer that they classify the batik patterns into two rooms because there are two types of patterns which are regular patterns and patterns which have no regularity. Then, the regular patterns mean that the patterns consist of repeating motif. It is possible to happen because the question is not clear enough for the students. Therefore, the question is revised from "*Jelaskan alasanmu dalam mengelompokkan motif Batik tersebut ke dalam dua ruangan*" into "*Tuliskan alasanmu dalam mengelompokkan motif Batik tersebut ke ruang 1"* and *"Tuliskan alasanmu dalam mengelompokkan motif Batik tersebut ke ruang 2*"
After getting the notion of regularity, the students investigate the batik regular patterns by using a mirror. It aims at supporting the students to be able to deduce the

characteristics of line symmetry from the regular batik patterns by using a mirror. In this task, the students only focus on investigating the regular patterns by using a mirror. Based on the HLT, the students are expected to put the mirror in the middle of the patterns and acknowledge that the mirror reflects the same pattern as the pattern which is covered. Then, they acknowledge that the position of the mirror refers to the axes of symmetry in which it divides the patterns into two identical parts and both of them are reflecting each other.

In doing the task, the students start to place the mirror in the middle of the patterns. They also count the number of mirror positions which result in the same patterns. However, the two groups start to argue when they have different number of mirror position of pattern D. Group 1 had four positions and group 2 had eight positions. Hence, they were asked to present how they place the mirror. Group 1 placed the mirror in the middle of the pattern vertically, horizontally, right and left diagonally. Meanwhile, group 2 not only placed the mirror like group 1 but also in the four edge of the pattern. Therefore, they had eight mirror positions as the result. Since this situation is already predicted in the HLT, the researcher responded it by placing the mirror in the edge of the pattern which have no regularity and asked the students whether the pattern look symmetric on the mirror. It is intended to make the students realized that the mirror positions in the edge of the pattern are not counted. As the students see that the reflection is the same as the pattern, then the researcher confront it with the regular patterns. The students start to realize that if they place the mirror in the edge of the pattern, every pattern (regular and no regularity) will look the same. They seem understand why they cannot count the mirror position on the edge of the pattern.

Then, in the whole group discussion, each group presents their result of counting the mirror position on the patterns. They also show how they place the mirror on the pattern. The following is the transcript of the discussion.

Researcher : "*how about pattern J, how many mirror positions that you got*?"
(*Emir and Nito present how they placed the mirror and count the number of positions*)
Nito : "*Ehm*...(*placing the mirror vertically*) *one*..".
(*placing the mirror horizontally*) "*two...there are two positions*"
Emir : (*placing the mirror vertically, horizontally and diagonally but he realizes that if he places the mirror diagonally, then the pattern will be different*)
"*just two*"
Researcher : (*talking to all students*) "*Are you sure, two or four*?"
All students : "*two"*
Researcher : "*Yes two, how about L*?"
(*every student place the mirror on the pattern L*)
Nito : (*placing the mirror vertically*) "*one*..."
(*placing the mirror horizontally*) "*two*"
(*placing the mirror diagonally*)
"*oh it is not. So, just two*"
(*Other students agree to Nito's answer*)
Researcher : "*Yes two, now don't you remember, what do you think about the mirror position, how should we call it*?"
All students : "*symmetry*"

Emir : "*line symmetry*"
Researcher : (*talking to Emir*) "*what, how do you call it*?"
Other students: "*symmetry*"
Adit : "*the axes of symmetry*"
Researcher : "*yes, the axes of symmetry*"

The transcript reveals the fact that the students can relate their prior knowledge of line symmetry which they learned in grade four with this hands-on activity. By observing how the students place the mirror in the pattern, they aware that they should place the mirror in the middle of the pattern. Then, by considering the details of the pattern, they can determine the axes of symmetry of the pattern. In other words, the hands-on activity in which the students are asked to find the required mirror position in the batik pattern can support the students to deduce the characteristic of line symmetry (the axes of symmetry).

Post-test

The post-test is conducted after finishing the preliminary teaching experiment. It aims at knowing their recent knowledge of symmetry after getting involved in the preliminary teaching experiment instead of comparing their prior knowledge with the recent ones. The following is the description of the students' recent knowledge based on the post-test's result.

1) The students can perceive a parallelogram as an asymmetric object. When the students were asked to determine the symmetric objects, they include a parallelogram as the symmetric ones. However, they were asked to state the reason, they stated they remember from the previous lesson that a parallelogram does not have the axes of symmetry. They are not able to give the mathematical reason in which the parallelogram only has diagonals and no axes of symmetry.
2) The students can differentiate between the axes of symmetry and diagonal. The following figure 10 shows that the students acknowledge that diagonal of the shape is not always becomes its axes of symmetry.

Figure 10. The Example of Students' Answer of The Post-test's Problem

CONCLUSION

In order to answer the research question, an activity which focuses on supporting students' understanding of line symmetry has designed. Based on the retrospective analysis of this first cycle, the activity can support students' understanding of line symmetry under particular conditions. In this activity, the concept of line symmetry is introduced by the concept of regularity which means repeating patterns. Hence, the students must have the same perspective toward the regularity of the provided batik patterns so that they can determine the regular patterns correctly. Then, in exploring the regular batik patterns, the students must place the mirror in the proper position so

that they can acknowledge that the mirror positions can make the patterns look like the initial ones. The mirror positions lead the students to the notion of axes of symmetry. In general, the designed learning activity is able to support students' understanding of the concept of line symmetry. However, the teacher should be the facilitator and guide during the learning process to ensure that the students discuss and do the tasks as the intended way. It can be done by posing relevant questions which lead the students to understand the concept of line symmetry.

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