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TANGRAM GAME ACTIVITIES, HELPING THE STUDENTS DIFFICULTY IN UNDERSTANDING THE CONCEPT OF AREA CONSERVATION PAPER TITLE

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Abstract

Providing formula too early is mostly done by the teacher in teaching area measurement topic. In fact, the students are still incapable to fully understand what the formula is. This situation is called the mismatch situation. Hence, remembering the formula of the area of shapes will be the only possible way by the students to proceed in the class. The Pendidikan Matematika Realistik Indonesia (PMRI), which is the adapted RME with Indonesian context, could be used to overcome the mismatch condition in Indonesian students. PMRI introduce the emergent modeling as mean to bridge the students' difficulty in achieving higher understanding on mathematics through guided reinvention and didactical phenomenology. In addition, several studies pointed out that the teaching of area conservation as the introduction in area measurement should be administered properly. Furthermore, van Hiele proposes that the use of puzzle could be promising in the topic of area conservation. Thus, we develop a series of learning activities in the 3rd grade class by using tangram as the main tools. The result of this research is that the activities provided in the learning trajectory could help the students in understanding area conservation. The students are still unable to do measuring using the idea of conservation. However, when they are asked to compare the given shapes, they successfully apply the concept of area conservation well using tangram idea. Moreover, they also experience a lively group discussion; in fact, the class is not accustomed with discussion.

Keyword: Area Conservation, Tangram, PMRI, Design Research

INTRODUCTION

The teachings in the topic of area measurement tend to give the formula too early to the students (e.g. Kordaki & Balomenou, 2006; Kospentaris et al., 2011; Papadopoulos, 2010). Inevitably, that results that the understanding of the students on the topic of area becomes merely procedural. Kordaki & Balomenou (2006) concludes from several studies that, in teaching the topic of area, the integration of teaching conservation area, unit iteration, and area formula is important for children. Nevertheless, these studies also suggest that the learning the concept of area conservation in the school curriculum is really fundamental before entering the big topic of area measurement. In fact, most of the pupils deal with confusion about decomposing problems (Kordaki & Balomenou, 2006). They cannot see that if we decompose a shape into another form, then the area remains invariant.

In Indonesia the topic of area conservation has no space provided in the school curriculum (Departemen Pendidikan Nasional [Depdiknas], 2003). Meanwhile, Kordaki & Balomenou (2006) suggest that the teaching in the topic of area requires the integration of teaching conservation area, unit iteration, and area formula. Omitting the concept of area conservation, could result the condition where the teaching of the teacher is not appropriate with what the students understand in their state. Where van Hiele (1985) call this condition as mismatch situation. Hence, for the students who do not fully understand the area measurement, they are only able to remember the formula. To help the students with the aforementioned situation, we try to develop a sequence of learning activities in order to provide adequate experience for the students in learning area conservation.

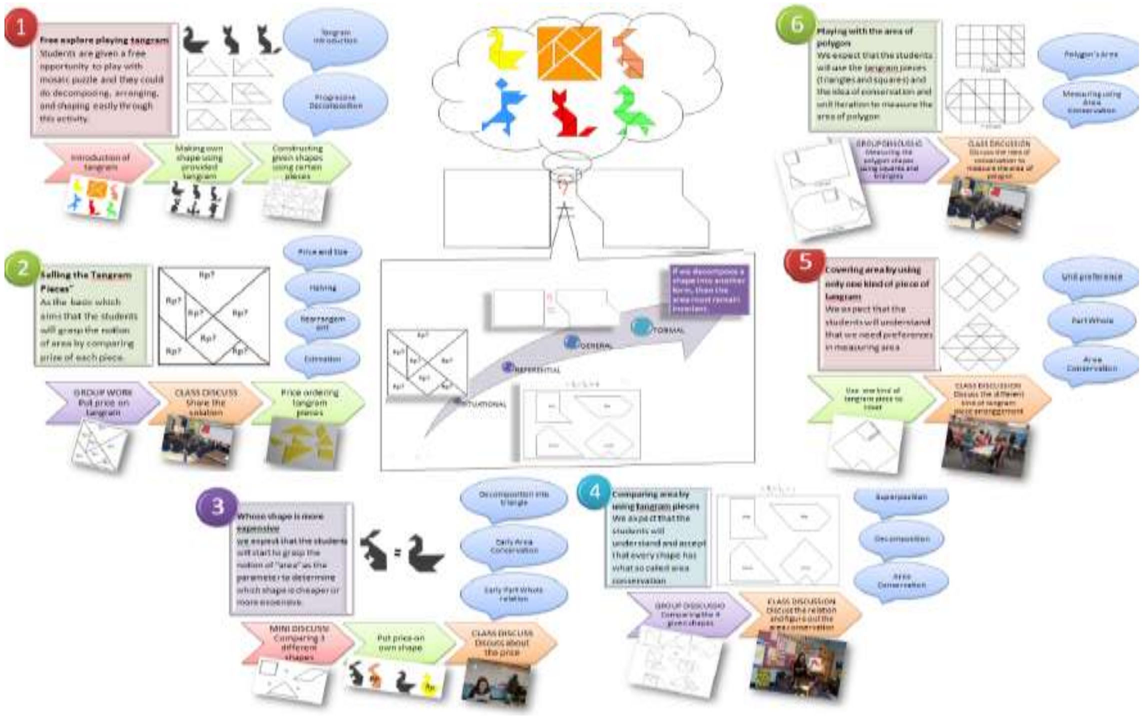
It is undeniable that the geometry topic in Indonesia heavily relies on the use of formula. The use of the formula and the properties of geometrical concepts in Indonesia is considered as procedural algorithm only without any meaningful knowledge (Fauzan, 2002b). S. M. Amin (personal communication, Augusts 9, 2012) also stated that the students only obtain the properties and the formula of geometrical figures during the teaching without considering the students' spatial conceptual understanding and reality. In addition, the students tend to be interested only in the formula or a shortcut. Inevitably, a non-meaningful learning could be resulted.

Area conservation means that the quantitative value of an area remains unaltered while its figure can be qualitatively new (Piaget et al., 1981). Nevertheless, this concept could be quite difficult to understand by the students. Furthermore, Piaget noted the difficulties of the students in understanding the area conservation. They are (1) subtracting and adding of the same parts and (2) decomposing and composing parts of shape into different shape, the students are failed to accept that the area remain invariant, because in their mind the shape is losing its continuity.

Understanding the concept of area conservation is defined as a process of giving meaning to its different representations numerically, visually or using symbols (Piaget et al., 1981). In detail, giving meaning to the concept of area conservation is closely related to the used tools and to the shapes on which they have to study. Therefore, the researcher defines the understanding of area conservation in this research as the activities of (1) using the tools, tangram pieces, to examine the existing area conservation in the rearrangement and (2) using the idea to examine the quantity of the irregular polygon area.

Using games and puzzles as non routine problems for the students could be promising activities to make mathematics become more interesting and fun. Van Hiele (1999) suggest that when using a mosaic puzzle as a games in studying certain shapes and their properties, symmetry, parallelism, and area, the students experience a playful exploration during the learning. One of eminent mosaic puzzle game is an ancient Chinese puzzle, tangram. It has 7 pieces which are moveable such that they can be decomposed and composed from one shape into another shape. (Jovanovic et al, 2009).

Realistic Mathematics Education (RME) suggests that we must construct the learning activities involving the parts of each constructed among guided reinvention, didactical phenomenology, and emergent modeling to help a better understanding of the students in the topic of area conservation (Gravemeijer, 2004). Freudenthal (1991) suggest that by guiding the students in reinventing both valuable knowledge and abilities, it helps them to learn those concepts easier. By using tangram puzzle, it is conjectured that the students could reinvent of area conservation by composing and decomposing the tangram pieces. During the activities where the students experience rich stimulating geometric activities by playing with the tangram. We expect that the students will gain the insight of area conservation in area measurement through the contextual learning activities (the didactical phenome). Here, the model of tangram by using price is developed to reason with the concept of area especially for the big idea of conservation. Then, we expected that it will become the model for reasoning the concepts of area and help them to solve area-related problems.



Picture 1, Playing Tangram Game as an Introduction to the Concept of Area Conservation

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Gravemeijer (2004) define the process of emergent modelling as the development of the model-of informal mathematical knowledge into model-for formal mathematical reasoning. In this research, the model is developed by using tangram with price as informal model within the concept of area conservation. Then, we expected that it will become the model for reasoning the concepts of area and help them to solve area-related problems. Furthermore, Gravemeijer describe the development of the model through 4 levels: (1) **Situational level**, the informal model will arise from the contextual problem given in the beginning of model development. In this level, the interpretation of the model really bounded into the context given as the background of the problem. In this research, the use of the "Pricing the tangram pieces" context is considered as situational level modeling. (2) **Referential model**, the model becomes available to be used for other context. In referential level, the interpretation of the model is no longer bounded with the former context. Here, the flexibility usage of tangram pricing model in determines which shape has the same price or not. The model-of the activity is formed. (3) **General level**, the mathematical concepts start to appear as a part of the model which is no longer need a context to be interpret. The model involves the mathematical relationship to derive its meaning. Here, the conjectured relationship between the price of a shape and its area start to arise as the generalization of tangram pricing model. The model-for mathematical reasoning emerges. (4) **Formal level**, this level is achieved when the students are able to reason independently from the model means that the formal level is obtained. A new structure of mathematical fact is developed and ready to be used for reasoning. The idea of area conservation by which focusing on the invariant value of area while the shape is composed and decomposed from a shape into another shape becomes common notion for the students.

A formal way of geometry teaching in Indonesia should be administered properly. The use of tangram game by exploring its properties by which we can freely manipulate it in various meaningful ways on different shapes might break the formal way of learning geometry in

Indonesia. This could guarantee a fun and meaningful activity for the children. The main competency that will be the focus in the end of this learning activities is the students are able to measure the area of regular and irregular polygon by applying the idea of area conservation. The hands on activities using tangram in inviting he students to reinvent the concept of area could ignite the students to do something real with the notion area conservation. Hence, we propose the following research question for this research, how can tangram game activities help the students in understanding the concept of area conservation in area measurement?

In answering that question, we use design research approach as the framework in developing local instructional theory. Because this study concerns about geometrical thinking, we also consider how Van Hiele level of geometry reasoning development could suggest a good learning trajectory. By which and the Realistic Mathematics Education Domain specific theory as the design guidance, the hypothetical learning trajectory was designed.

RESEARCH METHOD

The main concern of the researcher is to improve education in Indonesia by designing innovation and change on development of PMRI especially on the topic of area measurement. To reach this objective, we, then, decide to conduct design research for answering the question. Here, we not only can elicit the way of the methods work well, but also we can understand why they work well. The resulting outcome of this study is a sequence of learning activities which is crucial as the answer of the research question along with the local intructional theory on the learning of area measurement (Bakker & van Eerde, submitted). Gravemeijer & Cobb (2006) define 3 phases of conducting design experiment. These phases are described as follow,

1. ***Preparing the Experiment***

   Relevant present knowledge from both literature reviews and actual situations about a topic should be studied first (Bakker & van Eerde, submitted). This preliminary phase has a goal which is formulating hypothesized local instruction theory which will be carried out and tested in the experiment (Gravemeijer & Cobb, 2006).. Then, the sequence of learning activities as well as the hypothesized students' thinking and students' strategies, which is called the Hypothetical Learning Trajectory (HLT), is resulted. This HLT will be carried out and tested during the design experiment and could be adjusted to the students' actual learning.

2. ***The Design Experiment***

   According to Gravemeijer & Cobb (2006), the design experimental phase is aimed both to test and to improve the hypothesized local instructional activity. In this phase, the learning sequence of 4 lessons developed in the previous phase will be carried out in teaching experiment.

   The teaching experiment will be conducted in 2 cycles. In the first cycle, the experiment will be implemented in a small class consist of 6 students with the researcher itself as the teacher. the researcher's observations of the lessons and the written works of the students are documented in reports. The reports will emphasize on classroom discussions, reflections and interesting individual contributions by students to support whether the conjectures really fulfilled or some issues come out to revise the learning activities in some extend. These data are required to qualify the HLT before carrying out to the whole class experiment.

   The second cycle is the actual classroom design experiment. The learning sequence will be implemented by the teacher in his/her class. In the class, the researcher tries to capture the classroom activities of the whole class. In the same time, the researcher also has a focus group to be analyzed along with the whole class situation. The data collected from this second cycle will be analyzed and used as the final revision of the HLT. Also, to answer our research question, how our activities could help the students' understanding of the area conservation in area measurement.

3. ***Retrospective Analysis***

The retrospective analysis is conducted during the design experiment after each lesson is carried out by comparing the HLT with the Actual Learning Trajectory. According to Gravemeijer & Cobb (2006), this analysis is aimed to contribute on the development of the local instructional theory. From the data obtained from the lesson series, we consider which hypothesized learning occurs and which one does not. This is deliberately done to improve the HLT and to answer the research question. it is important to keep track how the HLT being adjusted and improved to make the analysis more transparent and tractable (Bakker & van Eerde, submitted). In detail, while implementing hypothesized learning, the researchers confront the conjectures activities with the actual learning activities that are observed. This reflection should be done after each lesson because it may lead to changes to the original plan for the next lesson. The results of the analysis will be used to draw conclusions, to answer the research question and to revise the original HLT.

RESULT AND DISCUSSION

The result of the first cycle suggests that the use of price context is really helpful to help the student in dealing with the notion of area conservation. However, unfortunately, they tend to still use mechanical approach to solve the problem than geometrical approach. By what I mean, they have difficulty in reasoning using geometrical picture or drawing. Nevertheless, they could use the price and calculate the total as the reasoning. This implies that the students were accustomed with mechanistic teaching approach. The conclusive standard procedure is heavily used by the students which result the fact that they could not solve the problem independently (Nelissen & Tomic, 1993). The context was also not considered as helpful idea in proceeding to solve the problem.

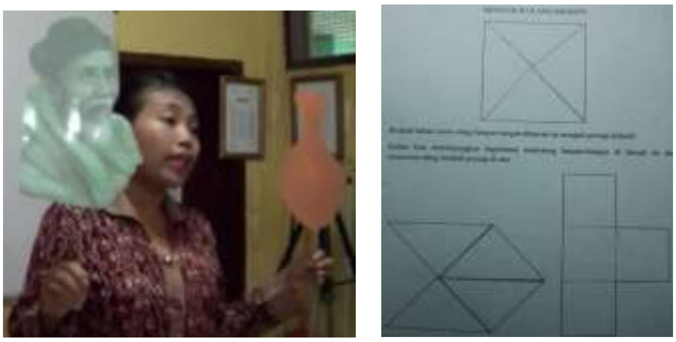
Picture 2, Students' Works – Working with Price of Shapes using Tangram Pieces

This finding is also parallel with the first 2 levels development of van Hiele's level of geometrical reasoning. The dealt with visualization level quite extensively. They did trial and error regardless the fact of geometrical fact of halving and combining shapes that can be used to help them in reasoning about the problem. However, they have a better performance in doing area conservation using geometrical reasoning when they deal directly with hands-on activity using geometrical figure (tangram puzzle) by giving the students the real feeling of area conservation. The use of tangram puzzle appends an experiential knowledge for them to enter the analysis level, second level of van Hiele's level.

In the second cycle, suggests that our HLT still need to be revised. Unexpected solution given by the students should be administered appropriately. The important ones are in the second activity where the students try to find the price for each tangram and the fifth activity where the students measure the shapes using triangles. The teacher guide should be also revised accordingly.

The teacher really supports how to make a nice class discussion. Several media which are used by the teacher like the picture of the tangram tale illustration, the big tangram model, and the use of power point to raise the students' interest work quite well. However, couple times the teacher did not do like what we have discussed based on the teacher guide. It is hard to ask the teacher to read our teacher guide carefully and perhaps to post some questions if the teacher guide is not clear enough.

About the students learning, our conjecture that tangram could help the student in understanding the concept of area conservation is correct. They could do decomposing a shape and recomposing it into another shape by dividing the shape into pieces like tangram pieces. However, to guide the student to use the idea of area conservation, it seems that our learning sequence still needs to discuss this issue more. But we believe that it would work due to the fact that the students could apply this idea when the teacher asked them how if we use are conservation in measuring area. Here, the guidance from the teacher is really important. The result from the post test also suggests a positive trend. The learning sequence would be more promising if we could add more activity for area measurement using conservation.



Picture 3, Teachers' Explanation of the Context and the Students' Work on the Conservation Problem

CONCLUSION AND SUGGESTION

In summary, the design could help the students in developing an idea of area conservation. Nevertheless, teacher guidance is really needed to ensure that the students really understand the concept. However, The design could not help much the students to use the concept of area conservation in area measurement. In my design, at least, they were busy in doing covering activities and not conserving the area.

In general, the tangram provides a nice opportunity for the students to understand the decomposition and the composition area. Furthermore, it also provides the students to relate the idea of price as the notion of area. It is surprising that the students directly decompose the shape into another shape because we expect they will cit and paste the shape. the designed learning sequence still could not invite the students to use area conservation as a big idea for helping them in measuring an area. It seems that we need more activities to help the students in using area conservation to measure area. By using the fact that the students could implement the partitioning of shape using the tangram pieces without the use of tangram pieces physical objects, we believe that the students will be able to use the tangram model to measure the area.

The analysis on this study suggests that area conservation for 9-10 year-old pupils is a difficult task. The use of price context is really helpful to help the student in dealing with the notion of area conservation. However, unfortunately, they tend to still use mechanical approach to solve the problem than geometrical approach. By what I mean, they have difficulty in reasoning using geometrical picture or drawing. Nevertheless, they could use the price and calculate the total as the reasoning. This implies that the students were accustomed with mechanistic teaching approach. The conclusive standard procedure is heavily used by the students which result the fact that they could not solve the problem independently (Nelissen & Tomic, 1993). The context was also not considered as helpful idea in proceeding to solve the problem.

The analysis also suggests that the use of scaffolding is important to help the students in measuring an area using the concept of area conservation. Asking a problem followed by supporting small activities as the scaffolding would help the students to understand the concept easily regarding the fact the students are accustomed with mechanistic teaching approach. This finding supports what Gagne believes (in Nelissen & Tomic, 1993) that, in mechanistic class; the students should experience a series of smaller progressive tasks before dealing with the complex one.

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