Design research on plane figure learning by using picture story and pairing game to improve mathematical communication skills of second grade of primary school students

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Design research on plane figure learning by using picture story and pairing game to improve mathematical communication skills of second grade of primary school students

Lisnani

Primary School Teacher Education. Universitas Katolik Musi Charitas, Jl. Bangau No.60, Palembang 30113, Indonesia

E-mail: Lisnanipcmtk@yahoo.com

Abstract. This research aims to produce the learning trajectory to improve mathematical communication skills of second grade students on the plane figure by using picture story and pairing game. It uses design research which consists of three stages: preliminary design, design experiment, and retrospective analysis. In the stage of preliminary design, researcher designed the Hypothetical Learning Trajectory (HLT). In the stage of design experiment, researcher then applied the HLT in teaching second grade students to improve mathematical communication skills from informal knowledge to formal knowledge through mathematics activities. The activities are picture story by using tangram context and pairing game. Finally, in the of retrospective analysis, the result of HLT application was analyzed to acquire the final result namely; Learning Trajectory (LT) of picture story and pairing game. Second grade students were involved as samples of this research. The data were collected through interview, observation, test, documentation, and field note. The data were analyzed through t*riangulation of data* and interpretation cross. The result of this research is LT of the plane figure by using tangram context picture story and pairing game to improve mathematical communication skills of second grade students.

1. Introduction

Mathematics is a discipline which has a specificity compared with other disciplines. Therefore, one who learns mathematics must notice the nature of mathematics. In the process of learning mathematics, the principle of learning must be chosen at the beginning, so that the process of learning mathematics can run smoothly [1]. Through this process, students are expected to improve the ability to use mathematics in problem solving and communicate ideas by using symbols, tables, diagrams, and other media. However, most students rarely practice their mathematical communication skills due to lack of understanding of the material. Therefore, the students are unable to re-explain the topic that they have been studied before.

This is in line with the result of the interview about mathematics conducted by the researcher with some elementary school teachers. From the interview, the researcher obtained information that some students have difficulties in understanding some topics in mathematics such as fractions, division, plane figure, and 3D dimensional shape. Dealing with the plane figure, some students find it hard to understand it due to the need for visual ability and high imagination. The plane figure is a part of

geometry. The theory underlying the geometry is Van Hiele theory which comprises five stages namely: visualization, analysis, informal deduction, formal deduction, and appropriateness. In response to this view, has highly recommended that teacher incorporates some shape puzzles such as tangram, lego, and Froebel's blocks in the plane figure as part of geometry teaching and learning activities [2]. Meanwhile, the tangram is a Chinese game consisting of seven pieces of plane figure namely square, right triangle, equilateral triangle, and parallelogram that form a big square together. Applies tangram in shaped images of animals, people, and objects to improve students' understanding of plane figure [3].

The researcher designed this tangram into a picture story by combining various pieces of the plane figure into the shape of animals, people, and objects. The use of tangram context picture story enhances students' interest in learning due to the use of colorful and unique picture story. The designing of picture story uses the scientific approach which stated in 2013 curriculum. Learning in scientific approach involves observing, asking, gathering information/trying, processing information/ associating, and communicating. Mathematical communication skill cannot be separated from the students' ability to read and present a topic in front of the class.

In relation to it, this picture story can be classified into integrative thematic learning. Here, students are expected to sense the interrelationship between Indonesian and Mathematics subjects. Furthermore, the researcher also uses a game which matches plane figures called "pairing game". Pairing game is a game that pairs up plane figure with the shapes, properties, perimeters, and areas of the plane figure. The use of tangram context picture story and pairing game were in line with the characteristics of *PMRI* (Indonesian Realistic Mathematics Education) which covers context or exploration phenomenology. The context which corresponds to the concept is indispensable in initiating learning and shifting learning approach from teacher centered to student centered [4].

The designing process of picture story and pairing game can be described as follows; (1) designing and developing complete HLT, (2) revising HLT after conducting the pilot test to produce LIT (Local Instructional Theory). Based on the descriptions above, the formulation of the research problem is: How is the role of LT through picture story and pairing game in improving second grade students' mathematical communication skills on plane figure material?

2. Literature Review

2.1 Plane Figure

Plane figure is bounded by straight lines or curves. It has only two dimensions of length and width. For example: square, rectangle, triangle, parallelogram, rhombus, trapezoid, and circle.

2.2 Van Hiele Theory

This theory explains the development of students' way of thinking in geometry learning which consists of five stages [5]. Table 1 describes five thinking level by Van Hiele.

Table 1. Thinking level by van Hiele

Thinking level by Van Hiele	Object thinking
Visualization	Shape and shape types
Analysis	Shape characteristics
Informal deduction	The relationship between the characteristics
Formal deduction	Deduction systems and the characteristics
Appropriateness	Analysis of deductive systems

(1) Ability to express mathematics ideas orally, in writing, and visually, (2) ability to interpret and evaluate mathematics ideas orally, in writing, and visually, (3) ability to use terms, symbols, and structures to demonstrate situation and mathematic problems.

2.3 Tangram

Tangram is an ancient Chinese geometric puzzle which has with seven pieces: two large triangles, one medium triangle, two small triangles, one square, and one parallelogram (shown in figure 1) [6].

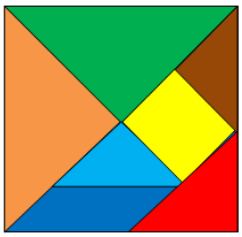


Figure 1. Tangram

2.4 Picture Story

Picture story consists of story and picture. The story is the core and the picture is the complement. Students can recognize the shapes of the plane figure through this picture story. In this research, the researcher used tangram context picture story in the shape of animals, human and objects (shown figure 2a). Figure 2b. describes the pieces of the plane figure in tangram context picture story.

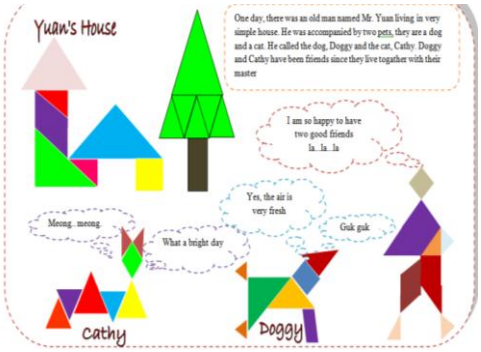


Figure 2a. Picture story using tangram context

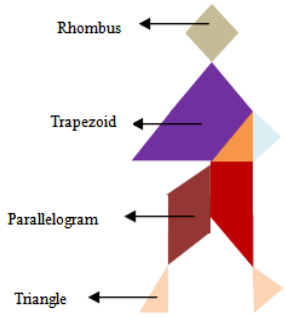


Figure 2b. Shape of plane figure in tangram

2.5 Pairing game

Pairing game is a game which matches plane figure with the shapes, properties, areas, and perimeters of plane figure. This game is played by the students in the group and the purpose is which its purpose to understand and communicate the plane figure within the group. This game uses cards consisting of the plane figure, shapes, properties, areas, and perimeters of plane figure (shown in figure 3).

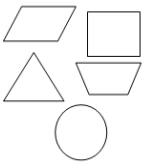
CARD 1	CARD 2	CARD 3	CARD 4
NAMES	SHAPES	AREAS	PERIMETERS
Trapezoid		*length times width*	*2 times (length plus width*
Isosceles triangle		*side times side*	*side times side*
Circle		*half times base time height*	*side plus side plus side*
Parallelogram		*phi times radius time radius*	*two times phi times radius*
Square			

Figure 3. Pairing game cards

2.6 PMRI Approach

PMRI (Indonesian Realistic Mathematics Education) is one of the innovations in the learning of mathematics developed in Indonesia since 2001. *PMRI* is an approach to learn mathematics that starts with the things that are 'real' for students. *PMRI* is implemented by using a real-world context, models, production and construction, interactive, and relatedness (intertwinement) [7]. The use of real-world contexts allows students to utilize their experience of capabilities and browsing new experiences.

The characteristics of PMRI): (1) phenomenological exploration or the use of context; (2) using models and symbols for progressive mathematization; (3) using student's own contribution and production; (4) interactivity; (5) intertwinement [4].

2.7 Mathematical Communication Skills

Communication can be interpreted as an event to convey the message or information to each other within a community [8]. In addition, revealed that the communication of mathematics is an essential skill in mathematic that is the ability to express mathematical ideas coherently to everyone through spoken language [9].

In this research, the indicators of mathematical communication skill which conforms to the needs of the researcher. The indicators can be described as follows; (1) the skills to express mathematical ideas orally and in writing, (2) the skills to interpret and evaluate mathematical ideas orally and in writing, and (3) the skills to use terms, symbols, and structures to model situations or problems of mathematics [10].

2.8 HLT and LIT

HLT is a hypothesis or prediction of how thinking and understanding of learners develop with a context in learning activities (shown in figure 4) [11]. HLT consists of three components: (a) the objectives of mathematics learning for students; (b) learning activities and tools or media used in the learning process; (c) conjecture of learning process, how to know the strategies and understanding of students that arise and develop when learning activities are done in the classroom [12].

LIT is a theory consisting of allegations about the learning process of learners that may be supplemented with assumptions about the aids that support the learning process [13].

Furthermore, HLT is a true relationship between an instruction theory and a true teaching experiment [14]. The conjectures of this relationship can be revised and redeveloped for the subsequent learning activities based on retrospective analysis after teaching experiments performed. Through LIT teachers can design HLT for a mathematics topic by selecting activities that correspond to the allegations that arise in the learning process. LIT is a frame of mind for designing and explaining HLT.

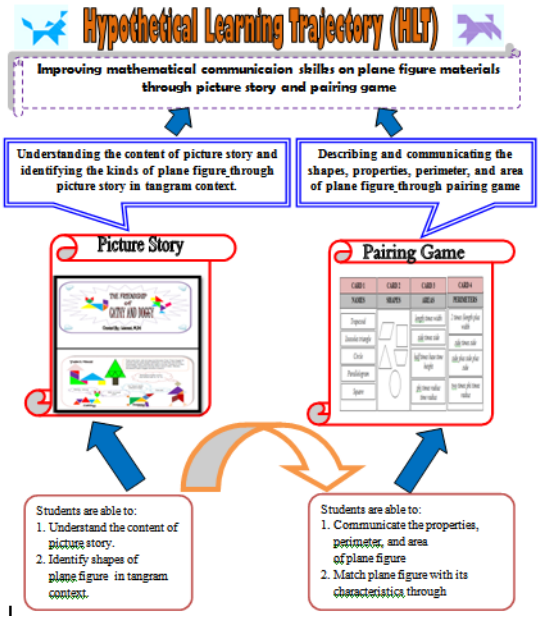


Figure 4. HLT

3. Methodology

3.1 Research Procedure

This research used design research which is appropriate to answer the research question and achieve research objectives. Design research is a research method that aims to develop Local Instructional Theory (LIT) with the cooperation between researcher and educator to improve the quality of learning. A series of student activities consisting of strategy conjectures and student thinking has been developed in this study [15]. There are five characteristics of design research, namely interventionist nature, process oriented, reflective component, cyclic character, and theory oriented [16].

Design research consists of three stages: (1) preliminary design, the main objective of this stage is to formulate local instruction theories that are elaborated and improved during the implementation of the experiment [13]. There is a series of activities that contains the conjectures of student thinking developed by researcher through HLT; (2) the design experiment, the researcher conducts pilot teaching activities that have been designed in the first stage. There are several activities undertaken including implementing the learning design with the aim of exploring, knowing the strategies and thinking of students in the introduction to plane figure material; (3) the retrospective analysis, the data obtained from teaching experiment were analyzed. HLT used in the retrospective analysis is the main reference and hint to answer the research question. In general, the purpose of the retrospective analysis is to develop LIT. The implementation of design research is also a cyclical process of thought experiment and instruction experiment [8]. The research is summarized in the following figure 5.

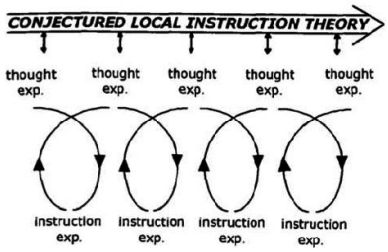


Figure 5. Conjectured LIT

3.2 Sample of Research

The sample of this research was twenty six students of second grade of SD Negeri 42 Palembang.

3.3 Data Collection and Data Analysis

In this research, the data were collected by interview, observation, written test consisting of early test (pre-test) and final test (post-test), documentation, and field note.

Data analysis was carried out with reference to the HLT. The data analysis is done in two ways: (1) triangulation of data is a technique used to see the correlation obtained from the data source in the form of field notes, observation sheets, and video recordings of the HLT that becomes the guide in conducting research; (2) interpretation cross of used to ask the considerations of counselors to advise on data obtained
as observation sheets and video recordings.

4. Result and Discussion

4.1 Pilot Experiment

In the pilot experiment class, the researcher only chose six students in grade IIA for pre-test. The researcher then obtained pretest results from the mathematics teacher in grade IIB that Annisa and Hafidz scored 90 representing high-ability students, Rika and Rafi scored 70 representing moderate level, and Gerry and Reni score 30 representing low level students.

From the pretest, it is obtained hat Gerry and Reni could not answer number 6a (shown in figure 6).

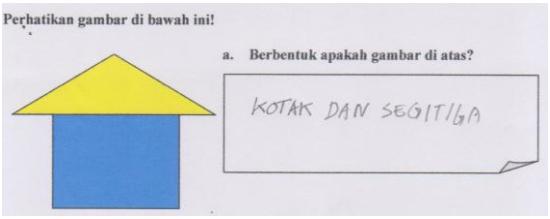


Figure 6. Student's answer for number 6a.

Figure 6 describes Gerry's answers: box and triangle. Based on the answers of the two students, it seems that the students did not understand and imagine the shapes of the plane figure picture on the item test for number 6a.

Then researcher continued first activity about the picture story with the students. Researcher distributed picture stories to the students. One of the students was asked to present an example of the picture in the picture story by communicating the plan figure that is on picture story figure 7.

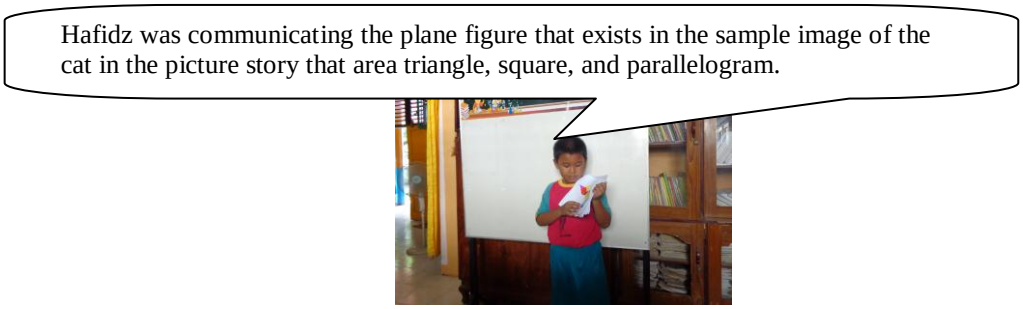


Figure 7. Hafidz's presentation on the first activity

In figure 7, Hafidz has not been able to distinguish the types of triangles. He only mentioned the triangles.

After having done the pre-test, the students were provided the first evaluation that consists of 2 item tests. It seemed that Reni was less able to answer the questions number 2 related to tangram as shown in figure 8.

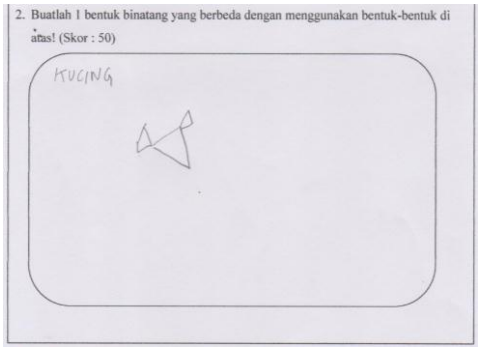


Figure 8. Reni's answer

Figure 8 described that Reni could not make plane figure model to be animal shape, person or object contextual tangram. Her answer was cat because she did not understand about the plane figure in the picture story by using tangram context. She only drew any shape. So, it can be concluded that

the indicator of mathematical communication skills is interpreting and evaluating mathematical ideas both orally and in writing have not yet appeared.

In the second activity, that is pairing game, students paired up plane figure with shape, properties, perimeter, and area of the plane figure. Most students have difficulties in pairing plane figure with shapes, properties, perimeter, and area. This is due to the lack of cooperation among groups. Therefore, the researcher did improvement of the second activity through retrospective analysis.

In the second evaluation on question 2, all students could not imagine how to arrange tangram with different shapes. In the pilot experiment class, it was found that some students were very seldom to communicate mathematically.

4.2 Teaching Experiment

In the teaching experiment class, the researcher took all students in grade IIA that consist of twenty six students. After pre-test, *teacher* obtained different results, that is, 30 percent of students obtained the score above 75 while 70 percent obtained the score below 75.

In the first activity students read the picture story. Then, one of the students presented the plane figure that is in the story (shown in figure 9).

Figure 9. Student's plane figure presentation

Figure 9 shows that students are able to mention the shapes of plane figure. It shows the indicator of mathematical communication skills are interpreting and evaluating mathematical ideas both orally and in writing, express mathematical ideas orally, writing, and visual have been able to appear.

Then, the teacher divided the students into five groups consisting of 5-6 students. Each group is given the activity of pairing the plane figure pieces and then presenting it in front of class (shown in figure 10a and figure 10b).

Figure 10a. Result of group 3

Figure 10b. Result of group 5

Figure 10a shows group 3 understands the shape and color of the plane figure and they can develop the idea. As a result, it shows the indicator of mathematical communication skills is in the form of using terms, symbols, and structures to model situations or problems of mathematics. While in figure 10b, students are less able to integrate the plane figure properly even though the results are almost the same.

In the second activity, that is pairing game, students matched the shapes, properties, perimeter and area of the plane figure. In the second activity, it shows the indicator of mathematical communication skills is interpreting and evaluating mathematical ideas both orally and in writing. Most of the students are able to match properly after the correction in the second activity in the retrospective analysis.

4.3 Retrospective Analysis

At this stage, the researcher corrects the items test on the second activity in the pilot experiment class. The item tests on second activity are less able to improve the skills of mathematical communication in pairing the plan figure with the properties. In addition, to improve students' ability in understanding the interrelationship plane figure with shape, properties, perimeter, and area of the plane figure.

5. Conclusion

On the basis of findings and discussions, it can be concluded that Learning Trajectory of picture story and pairing game generated from this research has an important role in improving students' mathematical communication skills on plane figure material. This role can be identified from a set of learning activities in the classroom.

At the first activity, the picture story aims to guide students in identifying plane figure shapes through a story and present it in front of the class so that the indicators of mathematical abilities arise. The indicators cover ability to express mathematical ideas orally, written, and visual and use terms, symbols, and structures to model situations or problems of mathematics. At the second activity, pairing game trains students' ability to understand the shapes, properties, perimeters, and areas of the plane figure so that the indicators of mathematical abilities arise. The indicators comprise ability to Interpret and evaluate mathematical ideas both orally and in writing. The set of activities above enables the students to understand plane figure both in theory and reality.

Furthermore, it is suggested for the next researcher to design complete HLT in order to generate LT which is not only improving the students' mathematical communication skills but also enhancing other mathematical skills such as mathematical creative thinking, mathematical reasoning, and mathematical concept understanding. In addition, it is better for the next researcher to find an ideal teacher.

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