

Building the Learning Path of Mathematical Creative Thinking of Students on Geometry Topics by Implementing Metacognitive Approach

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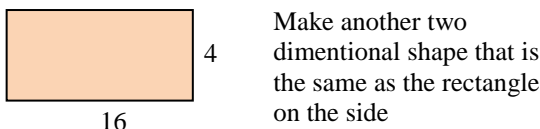
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Abstract—Prior knowledge becomes the most crucial thing that allows students to connect all existing information so that they can construct new knowledge through assimilation or accommodation processes. The aims of this research is to (1) analyze students' initial knowledge of what they miss or forget so they have difficulty answering the given geometry, (2) know the impact of Hypothetical Learning Trajectory (HLT) or learning path of creative thinking of students with the application of metacognitive approach. This type of research is Design Research in term of improving the quality of learning related to understanding the concept of Geometry. This study shows that prior knowledge becomes important to build students' mathematical creative ability to gain new knowledge of geometry. The most interesting topic is the area of the rectangle. The results of the study found that (1) the students were not creative yet or not able to get out of the existing flat pattern. Students are inseparable from the shape and drawing of the flat figure which is exactly the same as the available question, (2) there are five phases of learning path of hierarchical creative thinking of mathematics, that is orientation to problem, problem solving plan, plan realization, mastery of previous knowledge / concept of creativity mathematics and evaluation of the results obtained.

Keywords— mathematical creative ability, geometry, prior knowledge, metacognitive approach

I. INTRODUCTION

Problem solving is means of fostering students' creative thinking. One example of problems that can be raised to foster creative thinking of students and to demonstrate their creative thinking abilities as follows:



In the mind of creative students, if student A is able to draw a composite flat build that meets the same broad element as the rectangles given in the matter, then student A has fulfilled the novelty indicator; if student B is able to draw a triangle or parallelogram that meets the same broad element as the rectangle given in the matter, then he has fulfilled the flexibility indicator; and if student C draws a wake of another rectangle that has the same width as the rectangle in the matter, then it still fulfills the creative thinking component of the smooth component, because it is still fixed

on the shape of the rectangle or still following the existing pattern. Thinking is a necessary thing in a process that involves manipulating and transforming information in memory. In the process of solving mathematical problems students need to come up with creative ideas. [1] Based on book Wallas' "The Art of Thought" states that the creative processes are four stages: preparation (gathering relevant information), incubation (receiving inspiration), and verification (testing and assessing ideas acquired).

Metacognitive strategies in learning have a positive effect on the ability of creative thinking [2]. In line with [3] that metacognition is a strategy to apply and monitor model thought involving reasoning students and focused on the use of reasoning. In this case, clear that focus metacognitive strategy is precisely the students to be more creative. In addition, [4] state that meta-cognitive relates knowledge students their own thought and their ability to use learning strategies and their own special abilities appropriately. Therefore, learners can be taught strategies to assess their own understanding, calculate how long it takes to learn something and choosing an effective plan for learning or solve the problem. Based on this, it was clear that metacognitive strategies lead students to use reasoning (plotting many ideas of solution fit with problems, monitoring all problem solving, why I find it difficult to understand and master them and always think more than one answer and evaluate them) in solving mathematical problems. Here is an illustration of metacognitive strategies for acquiring creative thinking skills.

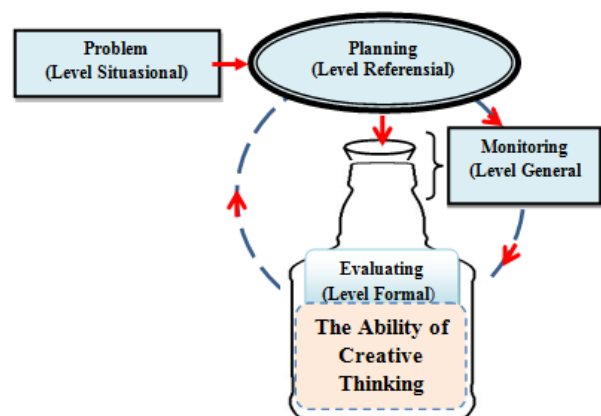


Fig. 1. Illustration of Metacognitive Strategies for Gaining the Ability of Creative Thinking.

Creative thinking is a fundamental way to be able to understand mathematical ideas. Students use creative thinking as a tool to assist their mathematical abilities by building abstract mathematical ideas into more concrete minds by using logical thinking, because creative thinking is a sign or configuration of marks, characters, or objects that mark and configuration to describe, or represent something other than himself. So this will support students in learning and communicating, connecting mathematical concepts to solve problems given. From this explanation, students who have low creative thinking skills will demonstrate the ability to generate ideas, question and respond to questions or arguments that are also low. This statement is also supported by some research results such as [5] students tend not to be able to give the reasons of the accusation is given. In this case the students are only able to give an educated guess without being able to give the right reasons.

Through learning with metacognitive approach in learning mathematics, habits of thinking about the mind trained by teachers and researchers in mathematics, contextual problems, teaching materials, discussion activities will be interrelated in influencing the development of creative thinking ability (CTA) in establishing student learning independence (SLI), and perceptions of learning. The linkage is illustrated as follows.

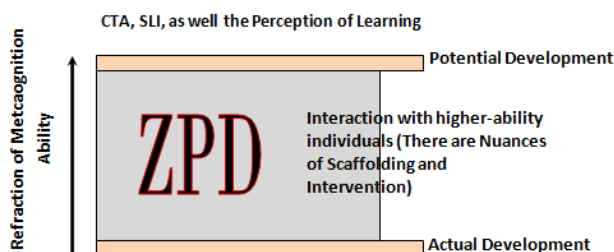


Fig. 2. Illustration of CTA Development, SLI, Perception of Learning.

One of the mathematical thinking habits constructed through learning with the metacognitive approach is to ask yourself whether there is "something more" than the mathematical activity that has been done. Such habits allow students to build their own knowledge or concepts and strategies to solve problems. If self-inquiry habits are trained continuously, it is impossible for student self-empowerment to increase. Such customs are in line with the philosophy of constructivism. Constructivism assumes that students must construct their own knowledge. In constructing the students' knowledge, scaffolding assistance is needed. In the context of learning, prior knowledge can be defined as the initial ability of a learner that can serve as a starting point to see how much behavior change that occurs after a person follows the learning process. This formula indicates that Prior Knowledge is not only related to the knowledge aspect but also about attitudes and experiences that a learner has.

Matsuda, et.al. Experiment in 2 different places. This study reveals that prior knowledge greatly influenced the learning process [6]. In addition, regression analysis shows that prior knowledge is the dominant facemask affecting post-test results for procedural ability testing. In addition, [7] also found that prior knowledge affected 81 students from two different classes who were treated differently in the form of game-based learning systems. It is also evidenced by (Bringual et al: 2016: 2) that prior knowledge in mathematics influences interaction with the system of learning and

capability demonstrations. From the explanation, it can be concluded that prior knowledge is one of the most important things to build new information in the minds of students. Also are some points that must be linked to make creative thinking of the information provided.

Geometry, an indispensable topic in mathematics, is regarded as a rich area to encourage problem solving and reasoning of students. [8]. To address the problem, students need to use representations of relevant information [9]. Relevant information comes from questions that can be connected to the information in the minds of students. Information in the minds of students is closely related to their existing knowledge of so-called prior knowledge. Students will use prior knowledge to create a visual image so that new knowledge will be more readily accepted at their cognitive development level.

Thus for every child may require learning trajectory or different learning path. Furthermore [10] provides an illustration of the learning path (learning trajectory) as shown below:

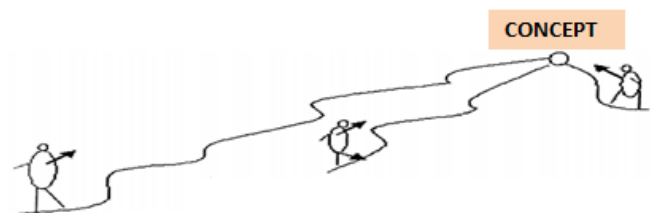


Fig. 3. An Illustration of the Learning Path.

The learning flow or better known as the learning path can help teachers in setting learning goals, and then plan the learning steps so that students can achieve the learning objectives. The importance of learning trajectory can be analogous to the planning of travel route. If we understand possible routes to the destination points, we can choose the best route to reach that destination. By knowing the learning path of the students, the teacher can design and get the proper learning path to use in helping students understand a concept.

The learning track or in English is Hypothetical Learning Trajectory (HLT). HLT consists of three components, namely learning objectives for students, learning activities and suspicion the process of learning how to anticipate thinking and understanding of students arising in the development of the learning activities are conducted in a classroom. [11] emphasizes the HLT character of guessing how students' thoughts will be formed when performing the activity and what reactions from students will occur in teaching experiments. The goal is to know the extent to which the actual learning path with the alleged trajectory has been made. This is in line with assertion that HLT is a combination of a learning theory and an actual teaching experiment.

II. METHODS

This research uses design research method with two tests as a way to answer the problem formulation so that the objectives are achieved. Design research is a research method aims to develop the of local teaching through collaboration of researchers with teachers to improve the quality of learning [12]. A series of student activities

consisting of strategy conjectures and student thinking developed in this study. In this study will be designed activities based on student experience is a familiar activity for students of class VIII SMP as an approach to understand Geometry.

This study consists of three stages with two repetitions that can be done repeatedly until found a new theory that is the result of a revision of the experimental learning theory. Here are the steps in research design.

Stage I: Preliminary Design, at this stage a literature study on rectangular materials and metaconitive approaches can be formed to form a strategy conjunction and trajectory of students' mathematical creative learning. At this stage also designed learning trajectory and hypothetical learning trajectory. Conjectures are dynamic and can be organized and revised during the teaching experiment.

Stage II: Teaching Experiment, in this second stage is to teaching activities that have been piloted is designed in the first phase in the classroom. At this stage a series of learning activities conducted then researchers observe and analyze what happened during the learning process that took place in the classroom. The kind of this research is design research with 2 trials as the good way to answer the the aims of research.

Stage III: Retrospective analysis, after the experimental data obtained from learning activities in the classroom are analyzed and the results of this analysis are used to plan activities and to develop the designs of the learning activities in the next. The purpose of retrospective analysis in general is to develop local level of learning. At this stage the HLT as compared to actual students and learning from here it can answer the problem formulation.

III. RESULT AND DISCUSSION

Figure 3 shows that, the improvement of each indicator of the ability of mathematical creative thinking of students ability is in experiment I namely the average ability of mathematical creative thinking on fluency indicator is 3.03, the flexibility indicator is 3.08, the elaboration indicator is 3.12, and on the indicator of originality is 2.67. In trial II, the average ability of mathematical creative thinking on the fluency indicator is 3.13, the flexibility indicator is 3.34, the elaboration indicator is 3.18 and the indicator of originality is 2.83. For more details can be seen in Figure 4 below.

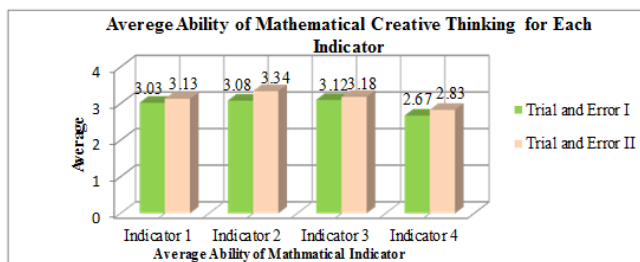

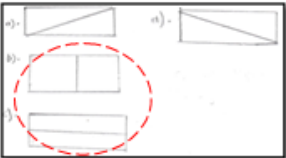
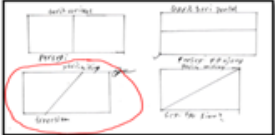


Fig. 4. The Average of Ability Mathematical Creative Thinking for Each Indicator.

From Figure 4, it can be seen that there is the average increase in the ability of mathematical creative ability in fluency indicator of 0.10, on flexibility indicator is 0.26, at elaboration indicator equal to 0.06, and at indicator of originality equal to 0.16. This shows the students' mathematical creative thinking ability using learning tools

developed based on metaconitive approach has increased from trial I to trial II. Here is an example of the problem and completion of the students in table 1 below:

TABLE I. EXAMPLE OF PROBLEM AND SOLUTION FOR CREATIVE THINKING

No	Questions and Answer (Aspect of Mathematical Creative Ability)
1.	<p>How would you divide a rectangle into 2 equal parts? Using ruler, scissors or other way to make as much as possible and draw the result!</p>  <p>Pattern and Variety of Student answers</p>  <p>In part answer b) and c) a flat wake image that is still fluency. Students still divide the rectangle into 2 equal rectangular sections or shapes and sizes, done in 2 ways, ie dividing paper paper horizontally and vertically or folded. Students are still not creative or can not get out of the existing flat pattern. Students can not be separated from the shape and the picture of the flat wake up is exactly the same as the problem available.</p> <p>While the responses of sections a) and d) the rectangular division into 2 equal triangles of equilateral triangles or their shape and size are not only fluency but have flexibility by means of folding or cutting both the rectangular diagonal corners opposite.</p>  <p>An interesting finding is the rectangular division into 2 equal trapezoidal sections, shapes and sizes, done in 2 ways, ie folding or dividing the paper tilted, students can already be creative even though they do not have the value of kebaharuan. Students are able to exit or no longer follow the available flat wake drawings.</p>

The students' creative learning path point as the findings of this research are 5 points of the track, ie orientation on the problem, problem solving plan, plan realization, previous knowledge mastery / mathematical creativity concept and evaluation of result obtained. Students do metacognition on the learning path of creative thinking in a comprehensive way from evaluation to planning, action to the formation of prior knowledge and selection of creative ideas. This finding is in line with developing seven stages of the creative thinking process, namely: orientation, preparation, analysis, ideas, incubation, synthesis, and evaluation. This means that the orientation to the problem as the starting point of the learning path of students' creative mathematics on the findings of this research is in line with opinion that someone doing problem orientation at the stage of the creative thinking process is the first step in the introduction of the problem. In addition, the researchers found that students metacognition activities in line with the opinion states that there are 3 ways to do metacognition in learning mathematics, namely belief or intuition, knowledge of thought processes, and self awareness in the independence of learning. One's beliefs influence the problem solving of mathematics in building a way / strategy to solve the problem. Knowledge of the thinking process refers to how effectively one uses his thinking process. While consciousness itself refers to the accuracy of a person in preparing what to do in solving math problems.



Fig. 5. Students Solve Problems with Own Initiative

When students are able to design, monitor, and reflect on their learning process consciously, in essence they will become more confident and more independent in learning. Learn self-reliance is a privately owned for students to continue their long journey in fulfilling the needsof average intellectual creative thinking mathematically for each indicator. The teacher's task is to develop ability of metacognition all students as learners, without exception.

The concept of metacognition is the idea of thinking about the mind to oneself. Includes awareness of what is known of someone (knowledge metacognition), what can be done someone (metacognition skills) and what is known about a person's own cognitive abilities (metacognitive experiences). Metacognitive ability is a knowledge procedure. This is what a person deliberately does to control cognition.

Before, students are assigned to solve problems related to rectangular properties; students must first understand them with real objects or rectangular images by mentioning what is in the rectangle so that students understand the meaning of the rectangle. Every point of the creative learning path must be passed by students to solve problems by finding mathematical creative solutions. To know each trajectory of creative thinking can be seen from the characteristics / behavior of students when learning activities take place, for example students always want to get a solution problem faced, want to get mathematical ideas and want to browse what information is known and asked from the problem. The full creative learning path point is presented in Learning Trajectory Table 2 below:

TABLE II. LEARNING TRAJECTORY THE RECTANGLE TOPIC FOR GRADE VIII AT JUNIOR HIGH SCHOOL

Period	Period1	Period 2	Period 3	Period4	Period 5
Topic	Persegi Panjang				
Sub Topic	Understand definition of the rectangle	Understand kinds of the rectangle	Understand kinds of the rectangle by picture	Identifying kinds of the rectangle and using to determine circumference and area	Solve a related problem in applying the rectangle properties determine the circumference and area
Many meetings	Meeting 1	Meeting 2	Meeting 3	Meeting 4	Meeting 5
Plan the Learning Activities	1. Observe the images or objects in the classes that are rectangular. 2. Draw a rectangle 3. Describes definition of a rectangle	1. Review from: The sides, corners, and diagonal. 2. Review from: 2 swivel and 2 symmetry the symmetry. 3. Review from: 4 ways to be paired to occupy their frames.	1. Review from: The sides, corners, and diagonal. 2. Review from: 2 swivel and 2 symmetry the symmetry. 3. In terms of: 4 ways to paired occupy the frame.	1. Lower circumference formula and the area of a rectangle. 2. Applying the formula to the circumference and the area of a rectangle based on the image rectangle. 3. Calculate the circumference and the area of a rectangle	1. Identify problems related to the circumference and the area of a rectangle. 2. Looking closely at the problems associated with application of the circumference and the area of a rectangle. 3. Solving real related round-and wide rectangle.
Note : Period 1, 2, 3, 4, 5 Timeline of learning Timeline of sub-topics					

IV. CONCLUSION

In answering the question of dividing the rectangle into 2 equal parts, the student is still not creative or yet can get out of the existing wake pattern. Students can not be separated from the shape and the picture of the flat wake up is exactly the same as the problem available. This is due to the lack of mathematical reasoning of the students at the time of verifying the answers already made.

There are five phases of learning trajectory of hierarchically creative mathematical thinking, which is orientation on problem, problem solving plan, and plan realization, previous knowledge mastery/concept of mathematical creativity and evaluation of result obtained. Students do metacognition on the learning path of creative thinking in a comprehensive way from evaluation to planning, action to the formation of prior knowledge and selection of creative ideas. From these explanations, teachers should also help ensure students have enough prior knowledge to make it easier to build new knowledge, as well as to make learning fun and meaningful so that students will remember knowledge in long-term memory. For the next researcher is how to build their previous knowledge that can support the learning of geometry in accordance with the time given in the learning process.

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