The qualitative effect of problem-based learning model toward students’ mathematical imitative and creative reasoning

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Abstract. Reasoning is one of the abilities needed in solving mathematical problems. Based on Lithner perspective, reasoning divided into imitative reasoning and creative reasoning. There are three indicators for each reasoning, that are plausibility, mathematical foundation, novelty for creative reasoning aspect and imitation for imitative reasoning aspect. The aim of this research is to analyze the qualitative effect of problem-based learning model toward students’ mathematical imitative and creative reasoning. In order to do so, we used descriptive qualitative methods by taking eighth-grade students (around thirteen to fourteen years old) in one of the Junior High School in Tasikmalaya. We used the data from a written test, observation and interviews. The results revealed that problem-based learning model suitable for students who have dominantly mathematical creative reasoning abilities. The characteristics of students who have dominantly mathematical imitative reasoning abilities prefer to be told rather than finding out. Based on the results, we conclude that each student has a different learning style according to his abilities.

1. Introduction
Reasoning is considered as an important ability to deal with mathematical problem. One of the standard processes that students must have is reasoning [1]. Reasoning can develop logical thinking abilities such as analyzing, proving, evaluating, explaining, concluding, justifying, and generalizing [2]. Other than that, reasoning is needed to understand mathematics, build a mathematical idea and provide evidence of the truth of the idea [1].

Based on [3,4] perspective, reasoning divided into imitative reasoning and creative reasoning. Imitative reasoning is the process of copying an example without originality [4]. In the sense that the students express previously learned algorithms, mathematical procedures or facts [5]. The kinds of imitative reasoning are memorized reasoning and algorithmic reasoning [3,4].

Creative reasoning is reasoning based on creativity. In mathematics learning, creative reasoning is a creative thinking activity characterized by the flexibility in thinking through a different approach [3]. Creative reasoning in the context of this research is the opposite of imitative reasoning [3]. In the sense that creative reasoning is the ability to produce something original and meaningful. Student reasoning can be categorized as creative reasoning if the student makes his own or remakes the settlement strategy, not limited to remembering the procedures given [5].
There are three indicators for each reasoning. The indicators of creative reasoning based on Lithner perspective are plausibility, mathematical foundation, and novelty. Plausibility and mathematical foundation represent the reasoning aspect. So, the indicators of imitative reasoning are plausibility, mathematical foundation, and imitation. Based on the previous study, we conclude that the indicators of imitative and creative reasoning can be presented as shown in Figure 1.

![Figure 1. The indicators of imitative and creative reasoning](image_url)

Creative reasoning ability is better than imitative reasoning [6], but imitative reasoning is still considered important and needed. Some problems can be solved using certain facts or algorithms, so imitative reasoning abilities are needed to solve them. In addition, several terms, symbols, notations, and facts of mathematics are standardized and cannot be changed or used freely for creative reasons.

In addition to genetic factors, creativity—also creative reasoning—can be obtained and developed through education [7]. The teacher must design and carry out learning well in order to develop students’ reasoning, both imitative reasoning, and creative reasoning. Teaching, textbook, and assessments may promote rote learning [4]. It all can also develop creative abilities. In order to do so, we can use problem-based learning to promote reasoning abilities.

The development of an effective reasoning process can be achieved through problem-based learning [8]. Yew [9] defines problem-based learning as a pedagogical approach that allows students to learn actively in meaningful problems. The teacher’s role in the problem-based learning model is to present problems, ask questions, and facilitate investigation and discussion. This study will analyze the diversity of reasoning that students have during learning with a problem-based learning model. This study becomes important to show that an overview of imitative and creative reasoning can be seen during the learning process with the problem-based learning model.

2. Methods
This descriptive qualitative study—a part of a larger qualitative study—aims to analyze the qualitative effect of problem-based learning model toward students’ mathematical imitative and creative reasoning. To do so, first, we designed learning devices. Next, we carried out learning in accordance with the plan of the learning device. Finally, we analyzed the data from the test, observation, and interviews during the learning process. The focus of the study is not limited to the final score of
students but also focuses on the process of solving problems during learning. The subjects in this study were 28 of eighth-grade students (around thirteen to fourteen years old) in one of the Junior High School in Tasikmalaya.

3. Result and Discussion
The lesson started with a group division, each group consists of four students. After gathering with each group, the teacher gives a problem in the student activity sheet. Figure 2 shows the problem given to students.

A wrapping paper measuring 0.5 m x 1 m. The price of one sheet wrapping paper is Rp. 3,000.00. Andi will wrap gifts measuring 10 cm x 12 cm x 20 cm using that wrapping paper. If the gift to be made is 500 pieces, then what is the minimum cost that Andi needs to buy wrapping paper?

**Figure 2.** The problem

Mathematical reasoning is the process of concluding problems solving based on logical statements [10]. Logical statements include those derived from propositions given and testing certain problem assumptions. In the first step, all students have shown the right reasoning process by writing information that is known and asked. The initial strategy written by students is divided into two types. The first strategy is to simply rewrite information as in Figure 3. The second strategy shows that students process information as shown in Figure 4.

Known: A wrapping paper measuring 0.5 m x 1 m. The price of one sheet wrapping paper is Rp. 3,000.00. Andi will wrap gifts measuring 10 cm x 12 cm x 20 cm.

Question: If the gift to be made is 500 pieces, then what is the minimum cost that Andi needs to buy wrapping paper?

**Figure 3.** The initial strategy in accordance with imitative reasoning

Figure 2 shows that students only copy questions by adding the word 'dik' which means the known information and the word 'dit' means the question. In this step, memorized students have used reasoning skills to distinguish which information is known and which information is asked. However, students do not fully understand what they have written. When it is stated that the size of the paper is 0,5 m x 1 m, students confuse which paper length and paper width. So even with a gift size 10 cm x 12 cm x 20 cm. Based on these measurements students cannot conclude that the paper is rectangular and the gift is cuboid. Students are also confused to determine the length, width, and height of the cuboid. Based on these facts, students have not been able to process information correctly, so students only copy the sentence contained in the problem. So Figure 2 is an overview of
imitative reasoning ability in determining the initial strategy. Unlike the case with students who make the initial strategy as in Figure 4.

**Figure 4.** The initial strategy in accordance with creative reasoning

The initial step as in figure 4 leads to the right reasoning process. Students are able to process information and use it correctly to solve problems. In addition to writing down information that is known and asked, students also do unit conversions on paper sizes from 0.5 m × 1 m into 50 cm × 100 cm. Student activities in converting units from meters to centimeters are activities that use imitative reasoning abilities [3]. Students use memorized reasoning by remembering the fact that 1 meter is equal to 100 centimeters. Students' decisions in converting units can be categorized as creative strategies in solving problems. The strategy used by students is purely from the idea of students without any direction from the teacher.

Although some students seem confused when solving problems, in the end, all students can solve the problem correctly. In addition to getting the right solution, all students can also provide conclusions from the learning process that has been carried out. Figure 5 shows one of the student conclusions. In addition to conclusions as shown in Figure 5, some students concluded that the surface area of the cuboid is $2pl \times 2pt \times 2lt$. Although different, the two conclusions are true, plausible, and accordance with the mathematical foundation.

**Figure 5.** Student conclusions
Students do not consistently use the same abilities in each problem faced. Each student will change along with the learning process implemented. Therefore, we cannot categorize students as individuals with imitative or creative reasoning abilities. We can only categorize student answers, without categorizing the individual.

During the learning process with problem-based learning, some students are not accustomed to active learning. Students who are not accustomed to active learning immediately ask the teacher for answers before reading the task properly. Some other students have been able to bring up creative ideas in solving problems and processing information correctly. Problem-based Learning model suitable for students who have dominantly mathematical creative reasoning abilities.

According to observations and interviews data, we conclude the characteristics of students who have dominantly imitative reasoning and creative reasoning. The characteristics of students who have dominantly mathematical imitative reasoning abilities are (1) prefer to be told rather than find out; (2) rely on memorization rather than understanding; (3) students are more passive in finding concepts independently because they find it difficult to find concepts; (4) students' abilities are static and depend on the information conveyed by the teacher. The characteristics of the dominant creative students are (1) prefer to find out and solve their own problems rather than being told; (2) rely on understanding rather than memorization; (3) feel bored and sleepy when teacher-centered learning; (4) students' abilities are dynamic, so they can solve different problems.

4. Conclusion
Imitative and creative reasoning are both important and needed. The qualitative effect of problem-based learning is the diversity of abilities used by students in solving problems. These abilities include mathematical imitative and creative abilities. The problem-based learning model has been able to provide an overview of students' imitative and creative reasoning abilities. Each student has a different learning style according to his abilities. Each ability, whether imitative or creative reasoning has its own characteristics. So, learning can be designed according to the abilities possessed by students.

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