Students’ imitative and creative reasoning ability in solving geometry problems

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Abstract. This research aims to analyse students’ imitative and creative reasoning in solving geometry problems. The reasoning is essential for students. The reasoning in the context of learning mathematics is needed to understand mathematical concepts, build a mathematical idea and provide evidence of the truth of the idea. The reasoning divided into imitative and creative. Indicators of creative reasoning consist of creativity, anchoring, and plausibility. The method of this research was qualitative descriptive research. The subjects in this research were thirty-four students in ninth grade around fourteen to fifteen years old who have studied about cube and cuboid. Data collection was done by tests and interviews. The results of the data analysis show how students solve geometry problems using imitative and creative reasoning. The student answers are categorized into three groups, student answers by imitative and creative reasoning, student answers by imitative without creative reasoning, and the last student answers by creative without imitative reasoning.

1. Introduction
The reasoning is important for elementary, junior, and high school students. The low reasoning and understanding of students can be a factor causing students to experience learning difficulties [1]. Reasoning can develop students’ logical thinking skills in carrying out actions, such as analyzing, proving, evaluating, explaining, concluding, justifying, and generalizing [2]. Based on the five standard processes determined by NCTM [3], the reasoning is the standard processes that students must possess. This research aims to analyze how students solve geometry problems using imitative and creative reasoning.

Some cases show that students only do a series of short exercises and practical assignments that have little to do with mathematical creative thinking skills. Related to this, many students only use memorization without producing something new and imitative reasoning still dominates than creative reasoning [4]. Students who only have mathematical imitative reasoning abilities are exemplified by Lithner like robots with poor memories [5]. Creative reasoning has advantages compared to imitative reasoning. Creativity itself is considered to have a close relationship with mathematics. Creativity is fundamental to the work of a professional mathematician. Professional mathematicians find and solve substantive and challenging problems in their work [6]. Middle School students are expected to have high creativity so that they can solve problems that are more challenging in the future as if a professional mathematician.
Creativity is one of the competencies needed in the 21st century [7,8]. A person's creativity can be developed through education. Even Dyers revealed that 66.7% of a person's creative abilities were obtained through education and another 33.3% came from genetic factors [9]. In contrast, 66.7% of intelligence originated from genetic factors and 33.3% due to education [9]. Creative reasoning is reasoning based on creativity. Creative in the context of this research is the opposite of imitative. Creative reasoning is the ability to produce something original and meaningful. In mathematics learning, creative reasoning is a creative thinking activity characterized by the flexibility in thinking through different approaches [1]. 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 [10]. The mathematical creative reasoning indicators in this research are (1) Creativity/novelty, (2) Plausibility, (3) Anchoring/mathematical foundation. Imitation has a relationship with creativity. Imitation is the lowest level of creativity [8]. Lithner defines imitative reasoning as the process of copying or following a model or example without any originality [1]. Besides, imitative reasoning can be considered as reasoning which basically copies the solution of a task, for example by copying a precise algorithm or remembering a fact [11]. Imitative reasoning is reasoning based on memorization or prior experience [4,12]. Imitative reasoning can also be considered by simple reasoning [13].

Imitative reasoning is characterized by an attempt to recall a fact or an algorithm. Imitative reasoning categories include copying examples in textbooks or remembering specific mathematical reasoning algorithms [4]. During learning, students memorize facts and algorithms, then try to remember the memorization and the algorithm when completing the task [12]. Imitative reasoning is superficial [4]. Imitative reasoning is only on the surface of reasoning and does not have the characteristics of reasoning in depth. From some information, imitative reasoning is a logical thinking process based on previous experience without any element of originality and novelty.

Imitative reasoning can appear by itself, whether in the form of memorization or algorithms [10]. Thus, imitative reasoning divided into two types memorized reasoning and algorithmic reasoning [13]. Memorized reasoning can be used to answer questions in the form of facts, definitions, and proofs. In memorized reasoning, students only recall the answer entirely or rewrite the answer. On algorithmic reasoning, students remember algorithms in solving problems. Students do not memorize all answers in detail as in rote reasoning which only copies answers. The algorithm is a detailed procedure, namely a series of instructions that can be done to solve a problem [14].

This research becomes important to show that mathematical imitative and creative reasoning abilities are needed in solving mathematical problems. The results of the research will describe how students use imitative and creative reasoning abilities. This research is also a reference for teachers to know about this kind of reasoning and use a learning approach that can enhance imitative and creative reasoning abilities.

2. Method
This research was conducted in one of the junior high schools in Bandung. The method used in this research was qualitative descriptive research. The subjects in this research were thirty-four students in ninth grade around fourteen to fifteen years old. All of the subjects have studied about cube and cuboid. The procedure in this research is (1) preparing research instruments (2) give a test to students (3) interview to confirm and analyze student answers. The instrument of imitative and creative reasoning used in this research is four items of an essay (e.g., see Figure 1). The researcher then analyses the results to show the imitative and creative reasoning possessed by students.
1. Selembar karton berbentuk persegi panjang seperti gambar di bawah akan dibuat menjadi balok tanpa alas dan tutup. Diketahui luas karton tersebut adalah 880 cm$^2$. Jika panjang balok yang akan terbentuk sama dengan lebarnya, bagaimana cara kamu menentukan volume balok terbesar yang mungkin dibentuk dari karton tersebut?

2. Luas permukaan sebuah kubus adalah 216 cm$^2$. Suatu balok memiliki lebar yang sama dengan panjang rusuk kubus, tinggi balok 3/2 kali lebar balok, serta luas permukaan balok 468 cm$^2$. Berapakah panjang balok tersebut?

3. Sebuah bak mandi berbentuk kubus memiliki panjang rusuk 1,4 m. Tentukan banyak air yang dibutuhkan untuk mengisi bak mandi tersebut hingga penuh.

4. Sebuah bak mandi berbentuk balok dengan ukuran panjang 1,2 m, lebar 0,8 m, dan tinggi 1 m berisi penuh air. Setelah digunakan untuk mandi, air tersebut berkurang sebanyak 336 Liter. Bagaimana cara menentukan tinggi air yang tersisa di dalam bak sekarang?

![Figure 1. The instrument of imitative and creative reasoning.](image)

3. Result and discussion

Before carrying out the test, the researcher gave four preliminary questions related to how to determine the surface area and volume of the cube and cuboid. 94% of students can remember the formula for surface area and volume of cube and cuboid, but not all students can use it to solve the problems given. From this fact memorizing a concept is not enough to solve the problem. Based on the results of the analysis several findings, student answers are categorized as in Table 1.

| Category                  | Percentage |
|---------------------------|------------|
| Imitative with creative   | 10%        |
| Imitative without creative| 36%        |
| Creative without imitative| 39%        |

Students' answers are categorized as imitative and creative when they use memorization and previous experience to solve problems creatively (e.g., see Figure 2). Figure 2. shows that students can solve problems creatively and use memorization related to formula and unit conversion from meters to liters.
2. Students who only use imitative reasoning can easily solve routine problems such as "determine the surface area of the cube with known length." To solve this problem, students only use memorization related to formulas and algorithms to determine the surface area of the cube (e.g., see Figure 3). Students have difficulty in determining the width of the cube based on the surface area and length of the cube that has been known because it is not in accordance with the concept memorized by students. Students also have difficulties when facing problems that are different from previous experiences.

Figure 2. Student answers categorized as imitative and creative reasoning.
Students’ answers are categorized as imitative without being creative when they only memorize the formula but cannot solve problems that are different from the formula or example was given (e.g., see Figure 4.a).

Figure 4. Student answers to question number 1.

Figure 4.a shows that S5 students solve problems according to the formula that he memorized. The initial strategy that students do is look for the length of the carton from the width and rectangular area that was previously known. The length of the carton he has been looking for is symbolized by ‘p’, which means the length of the rectangle. After that, the students substitute the values of ‘p’, ‘l’, and ‘t’ on the cuboid volume formula. After the interview, S5 said that the length of the rectangle is equal to the length of the cuboid. Based on the results of the interview, we concluded that S5 students' answers were classified using imitative reasoning without using creative reasoning. Students only follow an algorithm that matches the formula that they memorize.

In Figure 4.b the S3 students creatively make a line that divides the rectangle into four equal parts. S3 assumes that the paper length is the base of the cuboids with ‘l’ and ‘p’ cuboids which are ‘p’ of the length of the paperboard. S3 student answers categorized as answers that use creative reasoning but do not use imitative because they incorrectly use units of \( cm^2 \) for units of volume (see Figure 4.b). Student answers categorized creatively without imitative when students can use creative strategies to solve
problems but are constrained by memorization such as forgetting how to convert units from liters to $m^3$ (see Figure 5).

Figure 5 shows that students cannot solve problems correctly if they only use creative strategies without remembering a concept or fact. Therefore, students need to have imitative and creative reasoning abilities in order to solve every mathematical problem.

4. Conclusion
The student answers are categorized into three groups, student answers by imitative and creative reasoning, student answers by imitative without creative reasoning, and the last student answers by creative without imitative reasoning. Imitative reasoning is seen when students solve mathematical problems by remembering concepts, facts, or following the algorithms that have been taught. Creative reasoning is seen when students solve mathematical problems by choosing creative strategies in the process of solving problems. Routine mathematical problems can be solved using imitative reasoning abilities but non-routine mathematical problems require creative reasoning abilities. Referring to the result, this research concluded that the students’ must have imitative and creative reasoning to solve the problem completely.

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