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Creative Thinking of Junior High School Students in Solving Fraction Problems: Insights from Polya's Problem-Solving Steps

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ABSTRACT

This study aims to analyze the creative thinking ability of junior high school students in solving mathematical problems on fractions material based on Polya's procedure. This research used a descriptive qualitative approach with the subject of two students who were selected purposively. The research instruments were problem solving questions based on Polya's four steps and interview guidelines to explore students' creative thinking processes. Data analysis was based on three indicators of mathematical creativity, namely fluency, flexibility, and novelty. The results showed that both subjects were able to understand the problem and identify relevant information, but there were differences in the problem-solving strategies used. The subject tends to use one conventional strategy without exploring other alternatives, so it has not met the indicators of flexibility and novelty. Meanwhile, the subject was able to generate several ideas and try various solution strategies, thus fulfilling the indicators of fluency, flexibility, and novelty. In addition, it was found that difficulties in understanding the concept and visual representation of fractions also affected students' creative thinking process. This finding confirms the importance of implementing open problem-based learning and systematic use of Polya's procedures to develop students' creative thinking skills, especially on fraction materials. The results of this study are expected to be a reference for teachers in designing mathematics learning strategies that are more innovative and according to the needs of students in junior high schools.

Keywords: Creative thinking, problem solving, polya procedure, fractions

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INTRODUCTION

The ability to solve mathematical problems is a critical skill for educational advancement in the 21st century (La'ia & Harefa, 2021). Students are supposed to acquire higher-order thinking abilities that allow them to approach problems in novel and adaptable ways in addition to mastering formulas and methods. However, it does not only depend on the understanding of mathematical concepts; it also involves critical, analytical, and creative thinking processes used to solve problems (Ramadoni & Admulya, 2023). According to some experts, mathematical creativity combines logical reasoning based on intuition with divergent thinking, but it must be done with a consciousness of flexibility, fluency, and novelty (de Vink, 2022; Siswono, 2010; Sriraman, 2009). Developing mathematical creative thinking skills through creative activities in learning mathematics is very important. These mathematical creative thinking skills include the ability to solve problems and/or build thinking structures, express statements that are different from the usual deductive logic and come up with general concepts to unify what is important in mathematics.

Creative thinking and problem solving are two complementary competencies that are increasingly recognized as key in facing the complex challenges of the modern era. People with creative thinking capabilities can combine analytical aptitude with imaginative viewpoints to produce novel solutions (Rosen et al., 2020). There are three main components that are assessed in creative thinking skills, namely fluency, flexibility, and novelty. Fluency refers to the student's ability to produce different ideas by giving correct answers, while flexibility refers to students' ability to solve problems with a variety of ideas and different approaches, novelty refers to students' ability to provide unusual answers or answers that are completely new and different from existing methods (Silver, 1997 in Yunadia et al., 2023). This ability is particularly important in the idea generation and solution exploration stages, where cognitive flexibility and the ability to think out-of-the-box are decisive factors. In the context of mathematics learning in junior high school, these abilities are key for students to be able to deal with complex and non-routine problems (Siswono, 2010). Providing problems that are appropriate to the student's context will also encourage student creativity (Wulandari et al., 2024).

Creativity in mathematics can be measured by asking open-ended questions that allow for more than one correct answer. These open-ended questions encourage students to think flexibly and find various strategies for solving problems, thereby fostering creative thinking skills and making them more active in the learning process. According to Getzel and Jackson (in Sari et al., 2020), mathematical creativity emerges when students are given the space to explore various possible solutions to a problem. Through open-ended questions, students are not only required to find one correct answer, but also to present various methods and reasons behind their solutions. This is very important because each student has a different background of knowledge, perspective, and thinking style, so that the application of an open-ended problem approach can provide opportunities for all students to express their mathematical ideas more broadly and originally.

One of the popular methods of solving problems in mathematics is Polya's 4-step method that is include: identifying the problem, devising a plan, carrying out the plan, and looking back (Gulam & Arenas, 2024). According to Polya, taking the time to reflect and look back on what you've done can help you learn a lot about what worked and what didn't. This allows you to foresee which strategy to take to address future difficulties. Each stage in Polya's procedure provides an opportunity for students to show their creative thinking. For example, when developing a plan, students can explore more than one way of solving. At the reflection stage, they could assess more efficient solutions or even find alternative solutions. However,

the results of several studies show that students' mathematical problem solving skills are still relatively low, because students are generally only able to achieve one or two of the four indicators of mathematical problem solving skills. In line with research from Andayani & Lathifah (2019) suggests that students who have low problem solving skills are limited to understanding the problem, but cannot make mathematical models, choose a solution strategy, solve problems, and rarely re-examine the answer results. Therefore, a learning strategy or model is needed to improve the ability to solve math problems (Jayadiningrat and Ati, 2018).

Through learning mathematics, individuals, especially students, can develop accuracy, critical thinking, creativity, and the ability to reason logically in solving problems (Imaroh et al., 2021). In line with that, this research departs from the background of thinking about the need to improve mathematics learning outcomes as a response to the symptoms of weakening the quality of the process and results of mathematics learning, especially in the process of developing student creativity.

The selection of the fraction material itself was carried out because fraction material in junior high school mathematics is often a challenge for students because it involves abstract concepts that make students unable to connect the concept of fractions with real situations. According to Winanda (2024), many students have difficulty distinguishing between larger or smaller fractions and cannot imagine how a fraction can be separated or combined. In addition, students tend to have difficulty in understanding visual representations of fractions, such as number lines or pie charts, which should help them visualize the concept.

The purpose of this study is to analyze the creative thinking ability of junior high school students in solving mathematical problems on fractions using Polya's procedure. The results of this study are expected to contribute to the development of more effective mathematics learning methods, especially in improving students' creative thinking skills. In addition, the findings of this study can be a reference for teachers in designing learning strategies that are more innovative and in accordance with the needs of students.

METHODS

This study used a qualitative approach with a descriptive research type to analyze the creative thinking of junior high school students in solving fraction problems based on Polya's procedure. The subject retrieval technique was carried out by purposive sampling. Two students were randomly selected as participants to obtain an unbiased representation of students' creative thinking processes in solving fraction problems. Although the number of participants was limited, such a selection enabled the researcher to conduct an in-depth qualitative analysis of each student's problem-solving behavior based on Polya's problem-solving procedure. The research instruments included problem solving test questions designed based on Polya's four steps (understanding the problem, planning a solution, implementing the plan, and evaluating the results) and interview guidelines to explore students' thinking processes. The data collection procedure began with the administration of the problem solving test, followed by an interview to understand students' creative thinking process. Interviews were conducted using a structured format with open-ended questions to explore how students understood the problem, the steps they took, and the obstacles they experienced. Each participant was asked the same set of questions, which were designed based on Polya's four problem-solving steps to reveal students' reasoning and creative thinking processes.

There was 1 written test question that met the indicators of creative thinking. The indicators used include fluency, flexibility and novelty. Student answers will be analyzed based on the indicators presented in Table 1.

Table 1. Indicators of Creative Thinking

Indicators	Sub Indicators
Fluency	Can generate more than one idea or answer in solving problems
Flexibility	Trying to use different strategies or approaches in problem solving.
Novelty	Can produce solutions that are unique, different from those that are common or usually used by other students.

RESULTS AND DISCUSSION

The purpose of this study was to analyze the creative thinking ability of junior high school students in solving problems of fraction material using Polya's procedure on 2 students in depth. The results of the analysis of the two subjects, RN and IT, showed variations in the level of creativity and problem solving strategies used by each student.

At the stage of understanding the problem, both RN and IT were able to identify the known and questionable information from the problem clearly. Subject RN was able to identify the known and questionable information from the problem clearly. RN showed his level of understanding of the given problem. He can write down the data in the problem as shown in Figure 1.

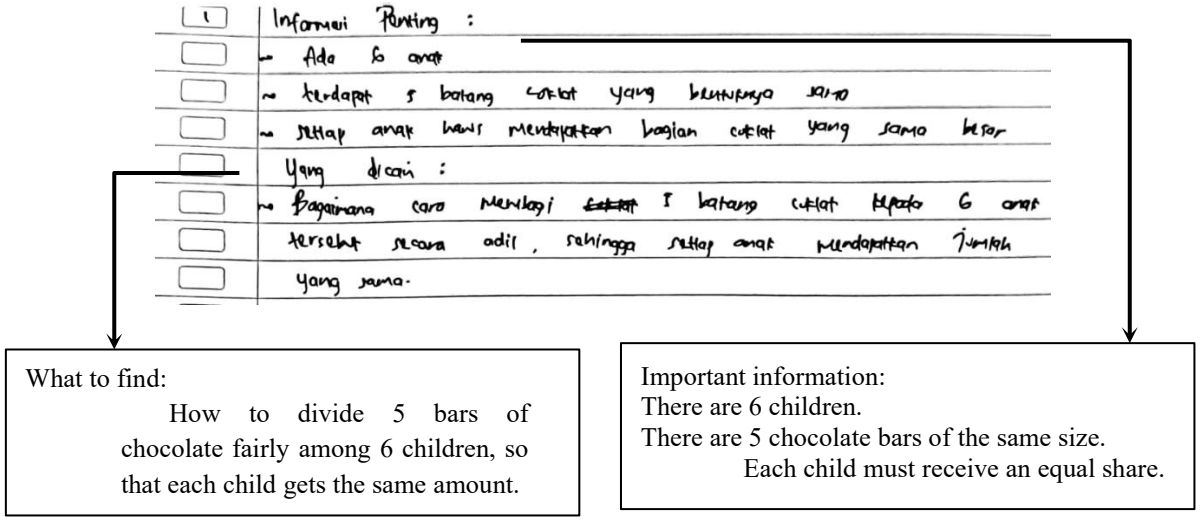

Figure 1. Answer to question number 1 from subject RN

RN's understanding of the problem can also be seen in the interview results, as follows:

Interviewer : "Explain briefly, what is the problem to be solved from the problem above?"

RN : "Must understand how to work on number 2 with 3 because the adjustment works on fractions and brown bar diagrams that are shared by the 6 children."

In the interview above, it can be seen that RN understands very well that the work on the problem given will be interconnected between the planning that will be made with the results of the division that he will do. But unfortunately RN could not fulfill the creativity indicator, namely novelty because the solution given was conventional, there were no unique or different ideas from those commonly taught.

At the stage of understanding the problem, the IT subject also gave good results. He can write down the data in the problem and understand the context of the given fraction problem as shown in figure 2.

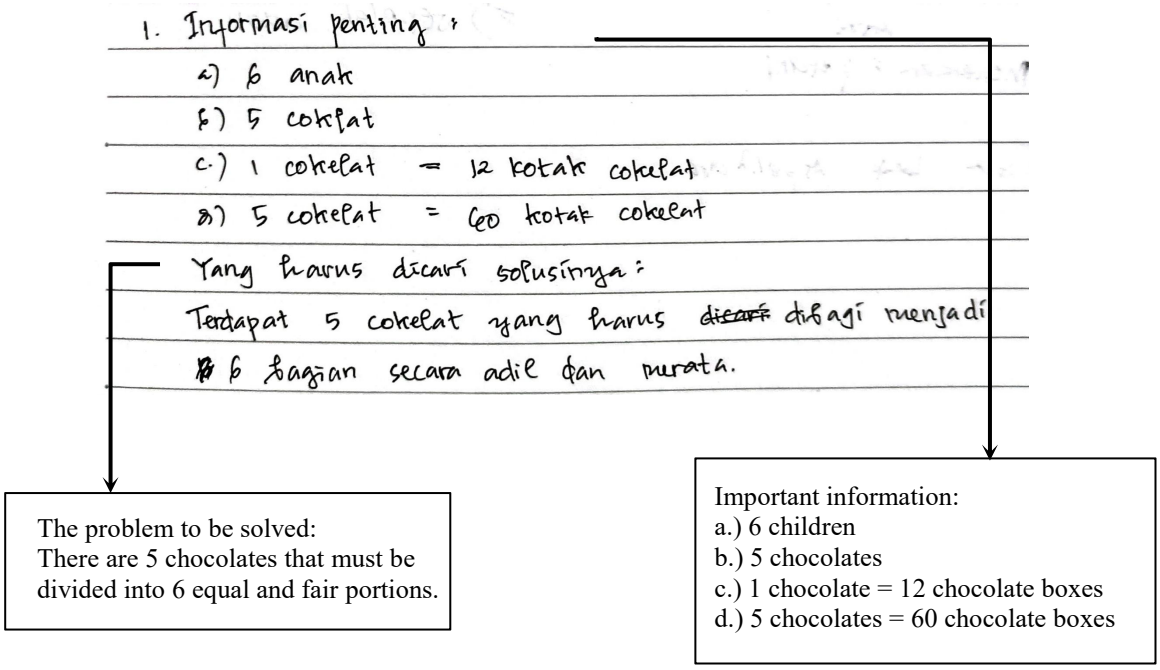

Figure 2. Answer to question number 1 from subject IT

IT's understanding of the problem can also be seen in the interview results, as follows:

Interviewer : "Explain briefly, what is the problem that must be solved from the problem above?"
IT : "Divide 5 chocolates to 5 children fairly and evenly."
Interviewer : "Do you think with that kind of chocolate, it can be divided fairly?"
IT : "It can."

The interview results show that IT understands the context of the given problem and IT has tried to calculate the answers that might be obtained.

Differences began to appear at the planning stage. RN tends to use only one strategy. Based on RN's answer as shown in Figure 3, she will solve the problem by dividing each chocolate into 6 equal parts then each child gets 5 pieces of chocolate that have been cut. However, RN did not try other strategies or explore different approaches. So that RN did not fulfill the creative thinking indicator, namely flexibility because there was no change in strategy when experiencing difficulties, so the flexibility of thinking was still low. This condition is in line with the findings of Andayani & Lathifah (2019) who stated that many

students are only able to understand the problem, but have difficulty in designing mathematical models and choosing various solution strategies.

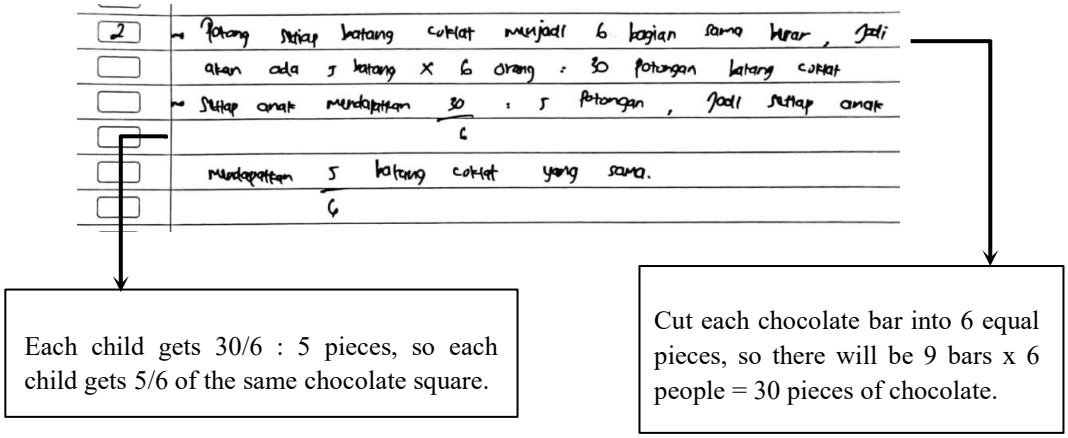

Figure 3. Answer to question Number 2 from Subject RN

In contrast, at the planning stage, IT showed the ability to design more than one strategy. Based on IT's answer shown in Figure 4, she will solve the problem by dividing each chocolate into 12 equal parts then each child gets 10 pieces of chocolate that have been cut.

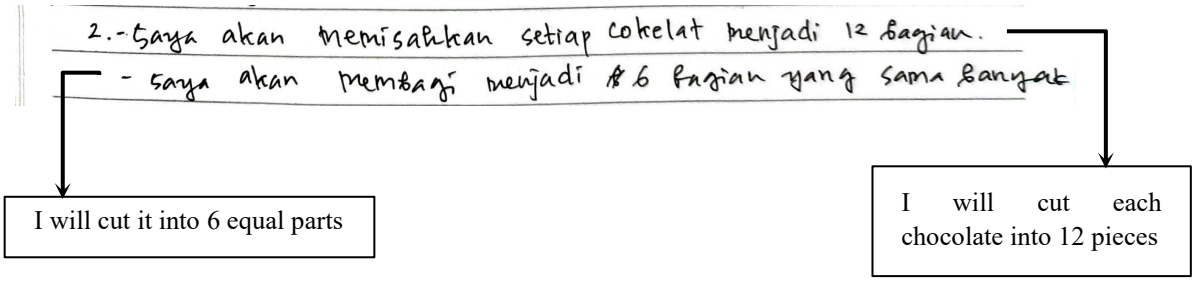

Figure 4. Answer to question Number 2 from Subject IT

In addition to the method he had written down, IT tried another way to divide the chocolate as he described during the interview:

Interviewer : "Do you have any other ideas on how to divide the chocolate?"

IT : "So, I have two other ideas, sis. The first one is that one chocolate bar has four small squares and three small squares. So, the first idea is, each chocolate bar is separated into four small bars. So, one row of four is immediately separated. So, split it all up, that's 15 pieces of chocolate. Each chocolate has four small bars. Then after dividing, each child gets 2 parts that contain four bars. After that, there are 3 rows of chocolate containing 4 small squares left. Each 1 part is divided into 2, resulting in 4 small squares divided by 2 distributed to six people. So the total is 2 long pieces of chocolate containing 4 bars and half a piece."

Interviewer : "Okay, what's the next idea?"

IT : "The second idea is to separate the chocolate into 3 small squares. So what is separated is that one long section is just a small box. So it was separated first and got 20 parts with 3 boxes. Then, each child gets 6 parts, each of which has 3 small boxes. Then, the remaining 2 parts are separated into 1 small box each.

Basically, each child gets 3 pieces of chocolate, which contains 3 small boxes, and 1 small box."

Based on the interview, IT can provide 2 other different ways to divide the chocolate fairly. So that IT fulfills the creativity indicator, namely Novelty. IT started to think of using different ways, although it has not fully produced a unique solution.

IT not only divided the chocolate into equal parts, but also tried two other different approaches in dividing the chocolate fairly. IT's ability to generate several alternative ideas and strategies shows the fluency and flexibility of creative thinking, as described by Siswono (2018) that creative students are able to generate many ideas (fluency) and switch strategies (flexibility) when facing challenges.

At the stage of implementing the plan, RN tried to draw the division of chocolate according to the plan, but the illustration results only copied the picture in the problem without actually representing the planned strategy as shown in Figure 1. Nevertheless, RN was still able to write the division results correctly.

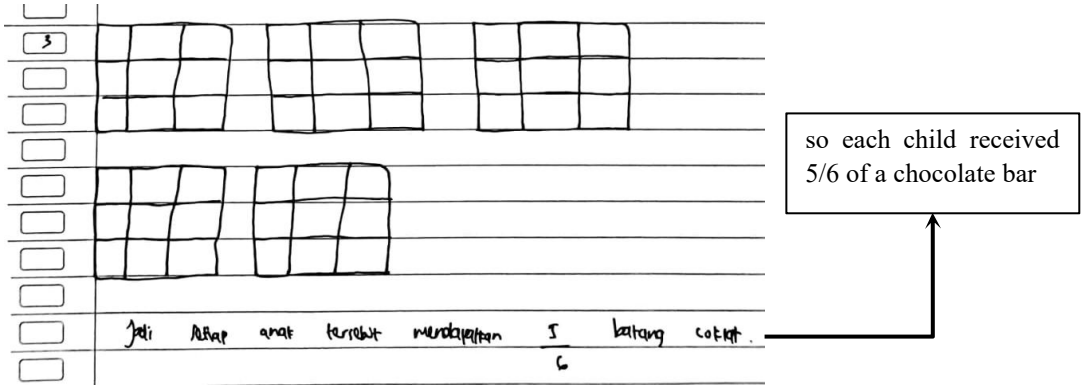

Figure 5. Answer to question number 3 from subject RN

IT, on the other hand, managed to draw an illustration according to the plan as shown in Figure 2. It can be seen that IT managed to make a picture illustration in accordance with the chocolate division plan that he had compiled, namely by drawing one whole chocolate and then dividing it into 12 small chocolate boxes. But unfortunately, IT could not write the fraction form of the division result that had been done.

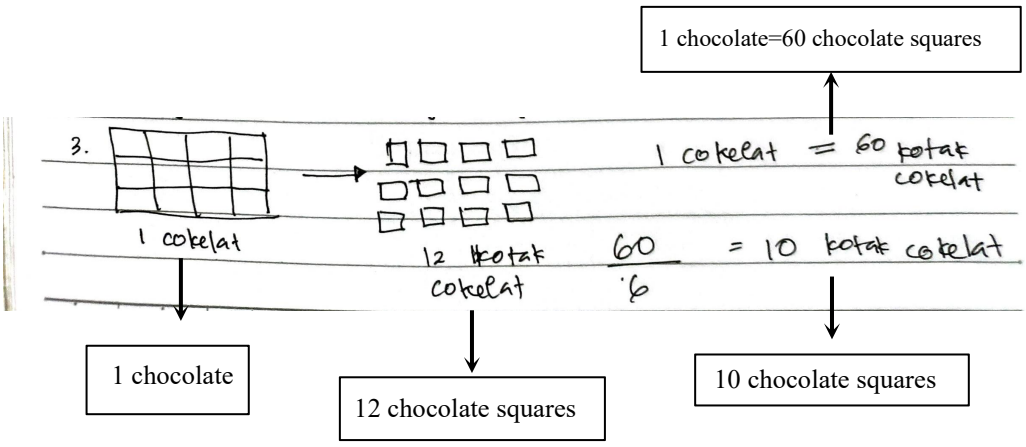

Figure 6. Answer to question number 3 from subject IT

Although not all of them can write the fraction form of the division result. IT is more able to realize creative ideas into concrete actions, although there are still limitations in the symbolic representation of fractions. so that IT meets the creativity indicator, namely fluency, IT tries more than one idea, although not all of them are done completely.

The evaluation stage also showed significant differences between the two subjects. RN only rechecked her calculation results without trying to find alternative solutions or comparing the results with other ways.

Interviewer : "Do you have any other ideas for dividing the chocolate?"

RN : "No."

The results of the interview above also show that RN did not fulfill the fluency indicator because RN only used one way (picture illustration) without trying other alternatives. Meanwhile, IT not only checked the results, but also actively sought and compared alternative solutions that she had thought of. Based on the interview results at the stage of making a solution plan, IT has also provided 2 different additional ideas which indicates flexibility because IT can provide another solution strategy that is different from the first strategy. If a student's creative thinking ability is high, then he will be able to show many different alternative answers to each problem (Handoko & Winarno, 2019). This shows that IT fulfills the novelty indicator, which is able to produce solutions that are unique and different from the initial strategy, in accordance with the creativity indicators proposed by Siswono (2018).

In general, the results of this study indicate that the creative thinking skills of junior high school students in solving fraction problems are still very varied. Students who tend to be conventional like RN only use one strategy, lack flexibility, and do not show novelty in the solutions produced. Meanwhile, students like IT show the potential for fluency, flexibility, and novelty, although it is not yet fully optimal in symbolic representation. Thus, the creative thinking ability of each student is different (Pratiwi et al., 2022; Romadani, 2023).

Damayanti (2018) explained that there are differences in students' mathematical creative thinking abilities at each level of education. These results confirm the importance of mathematics learning that emphasizes the exploration of various problem-solving strategies and the provision of open-ended problems, as suggested by Siswono (2018), so that students are accustomed to thinking creatively and are not fixated on one way of solving. The results are also parallel to the study conducted Yapatang and Polyiem (2022) where the study yielded positive results in terms of learners' ability to solve mathematical problems effectively by using Polya's problem solving strategy. Apart from that, it could be that students' creative thinking in solving problems is influenced by various factors, one of which is differences in learning styles (Rusmana & Shodikin, 2024).

Thus, developing creativity in mathematics learning not only improves students' academic ability, but also equips them with the thinking skills needed to face future challenges. Those who possess creative thinking skills are better prepared to overcome challenges and thrive (Mariani & Dewi, 2025). Teachers, schools and the surrounding environment need to work together to create an educational ecosystem that supports the growth of creativity and innovation in every learner.

CONCLUSION

Based on the results of the data description and discussion described in the previous section, it can be concluded that junior high school students are able to show indicators of creative thinking ability in solving fraction problem solving problems. Subject RN was able to

fulfill the fluency indicator but had not shown flexibility and novelty in the solution strategy. Subject IT was able to fulfill the indicators of fluency, flexibility, and showed the potential for novelty in the problem solving approach. This shows that creativity in problem solving is individual and influenced by the strategies and ways of thinking of each student.

However, this study has several limitations. First, the limited number of subjects causes the results of the study to not be widely generalized. Second, data collection was only done through interviews and task analysis, so it did not cover other aspects such as the influence of the learning environment or individual motivation as a whole.

Therefore, it is recommended that future research involve more subjects with varied backgrounds and use a data triangulation approach to obtain a more comprehensive picture of students' creative thinking skills. In addition, teachers are expected to provide more open-ended problems and space for exploration of ideas in mathematics learning to encourage the development of student creativity.

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