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The Exploration of Mathematical Creative Thinking Ability in Solving Geometry Problems from the Perspective of Mathematical Ability

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Abstract

Creative thinking abilities are developed through divergent thinking in mathematics learning. This research aims to explore junior high school students' mathematical creative thinking abilities in solving geometric problems, specifically in terms of their overall mathematical abilities. This study is a qualitative descriptive research project. The subjects were 27 eighth-grade students from a state middle school in Loghia District. Data were collected using tests and interviews. The findings indicate that junior high school students with high mathematical abilities demonstrated creative thinking in solving geometric problems. In contrast, students with moderate and low mathematical abilities showed less creative thinking, particularly when answering questions about surface area and volume. Specifically, there were 3 students identified as creative, 4 students as less creative, and 20 students as not creative. Overall, most junior high school students were not creative in their approach to solving geometric problems. They struggled to demonstrate indicators of creative mathematical thinking, such as fluency, flexibility, and novelty.
Keywords: *Mathematical Creative Thinking Ability; Mathematics Ability; Geometry.*

1. Introduction

Revolution 4.0 demands graduates who can communicate effectively, collaborate well, and exhibit creativity in advancing their fields (Maryanto &; Siswanto, 2021; Siregar et al., 2020). This creativity develops through cognitive processes that enable solving problems that require diverse solutions (Nurkamilah &; Afriansyah, 2021; Nisa & Amalia, 2021). Thus, having creative thinking skills allows a person to think beyond conventional boundaries and come up with original and novel solutions to problems. (Purwasih, 2019).

A person's ability to provide solutions to diverse problems and find new ideas illustrates their creative thinking. Creative thinking involves drawing conclusions that produce valuable and novel results. (Dalilan &; Sofyan, 2022). Creative thinking is essential in mathematics. Teachers must equip students with the skills to make decisions, ask questions, and solve meaningful problems to grab their attention and engage them effectively (Pangestu &; Yunianta, 2019).

The ability to think creatively in mathematics involves solving interrelated problems by measuring three indicators: fluency, flexibility, and originality. (Silver in Triyani &; Azhar, 2021). If learners have high creative thinking skills, they can demonstrate multiple and varied approaches to solving any problem that arises (Handoko &; Winarno, 2019; Suripah &; Sthephani, 2017).

Some research indicates that students' mathematical creative thinking abilities are still low. For example, research conducted by Andiyana found that junior high school students in Ngamprah Village are still less creative in spatial reasoning, with an average creativity percentage of 51% (Andiyana et al., 2018). Other studies have found that students have not yet reached the level of creative thinking when solving problems involving systems of linear equations in two variables (Dewi Aulia Rahmawati &; Firmansyah, 2023). Furthermore, the creative thinking skills of eighth-grade students in one of the junior high schools in Mataram, particularly in building space materials, are classified as less creative (Ermayani et al., 2023).

Field observations at a public junior high school in Loghia sub-district reveal that learning activities primarily focus on students, who work collaboratively in groups to solve problems from their Learning Activity Sheets (LKS). However, the questions provided tend to follow a predictable pattern: they align closely with the material taught and are often accompanied by examples from the teacher. This approach, while structured, limits students' opportunities for creative thinking based on their prior mathematical experiences. Instead, it reinforces the memorization of problem-solving techniques demonstrated by previous teachers. Preliminary analysis suggests that current mathematics instruction fails to stimulate students' creative thinking. Further interviews with mathematics teachers confirm that students struggle, particularly with geometry problems. Many students rely heavily on memorized formulas when determining solutions, rather than engaging in deeper problem-solving strategies (Dalilan &; Sofyan, 2022). When confronted with questions requiring reasoning or those classified as non-routine, students often encounter difficulty in finding solutions. Consequently, they tend to rely on memorization and the direct application of formulas to solve mathematical problems.

The creative thinking abilities of every student vary, influenced by factors including their proficiency in mathematics (Faturohman &; Afriansyah, 2020). As students' mathematical ability increases, their thought processes become more systematic and deliberate in planning problem-solving strategies, leading to greater creativity (Tohir et al., 2018). Research indicates a direct link between students' mathematical abilities and their tendency towards creative thinking; higher mathematical proficiency correlates with higher levels of creative thinking (Subur, 2016; Shahara &; Astutik, 2021). Consequently, individuals with differing levels of mathematical competence demonstrate distinct creative thinking processes. (Rani & Dalal, 2013). Therefore, to investigate this relationship, this study aims to explore the capabilities of mathematical creative thinking in solving geometry problems, with a focus on students' mathematical ability.

2. Method

This study employed a qualitative descriptive method to investigate the mathematical creative thinking ability of eighth-grade students in solving geometry problems, with a focus on their mathematical ability. The study included a total of 27 eighth-grade students as participants. The selection of eighth-grade students as subjects for this study is based on the fact that they have previously studied geometry topics, specifically surface area and volume. The research procedure comprised three stages: preparation, implementation, and data analysis The study initially categorized students' mathematical abilities based on their test scores from odd semesters. The criteria for categorization followed the conversion scale established by Ratmanan and Laurens, with high ability students scoring between 80 and 100, medium ability students scoring between 60 and 79, and low ability students scoring below 60 $(80 \leq x \leq 100, 60 \leq x < 80, 0 \leq x < 60)$ (Maharga, 2019). Based on the categorization of mathematical ability, 3 students were classified as having high mathematical ability, 4 students as having medium mathematical ability, and 23 students as having low mathematical ability. In the preparation stage, researchers collected problems related to surface area and volume of building space, guided by indicators of mathematical creative thinking ability, including fluency, flexibility, originality, and elaboration. In this study, students were tasked with answering four creative thinking problems. Subsequently, their responses were analyzed to assess the level of creative thinking ability based on mathematical proficiency. Interview subjects were selected using purposive sampling techniques, considering students' communication skills. Specifically, one student with high mathematical ability, one student with medium mathematical ability, and two students with low mathematical ability were chosen for interviews. The data analysis techniques in this study involve three stages: data reduction, data presentation, and drawing conclusions. The criteria for evaluating the level of mathematical creative thinking skills include five categories: very creative, creative, moderately creative, less creative, and not creative, as outlined in the following table (Siswono, 2018).

Table 1. Criteria for Mathematical Creative Thinking Ability

Criterion	Description
Level 4 (Highly Creative)	All indicators, including fluency, flexibility, and novelty, were met in solving the creative thinking problems
Level 3 (Creative)	The indicators of mathematical creative thinking, such as fluency and novelty, or fluency and flexibility, were fulfilled in solving creative thinking problems
Level 2 (Moderately Creative)	An indicator of flexibility or novelty was fulfilled in solving creative thinking problems.
Level 1 (Less Creative)	Only the fluency indicator is met in solving creative thinking problems
Level 0 (Not Creative)	The indicators of mathematical creative thinking are not met

3. Results and Discussion

Data on mathematical creative thinking ability were collected and analyzed to evaluate students' performance in terms of mathematical ability. The following graph presents an overview of the data on the level of mathematical creative thinking ability categorized by mathematical proficiency.

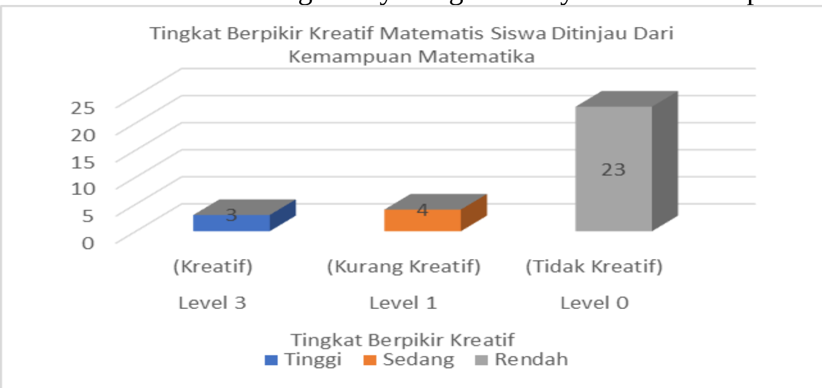

Figure 1. The level of mathematical creative thinking of students is reviewed from mathematical ability

According to Figure 1, in completing the surface area and volume of building space problems, high-ability students demonstrated a mathematical creative thinking ability classified as level 3 (creative). These students, with strong mathematical skills, exhibited fluency and flexibility in problem-solving. On the other hand, moderately capable students were identified as achieving level 1 (less creative) in mathematical creative thinking ability. Students with low mathematical ability were found to have a level of mathematical creative thinking at level 0 (not creative). These findings indicate that a significant portion of students lack creativity in determining solutions for problems related to surface area and volume of building space, particularly among those with low mathematical ability. This finding aligns with Dalal and Rani's belief in the strong correlation between students' intelligence and creative thinking (Rani & Dalal, 2013). There is a perception that students with high intelligence levels are often considered to be more creative. (Utami et al., 2020; Christofel et al., 2022). This implies that students' mathematical ability significantly influences their creative thinking when encountering mathematical problems.

Students with high mathematical abilities typically engage in a structured creative thinking process, which involves understanding problems, generating alternative solutions, formulating and implementing plans, and evaluating outcomes. However, despite their proficiency, some students may struggle to express their thoughts on given problems, perceiving them as too challenging. Several students, as narrated during interviews, expressed difficulty in connecting new problem types with previously learned concepts. They find it challenging to apply their knowledge beyond the specific information provided in the questions. Consequently, they tend to rely solely on memorized formulas for calculating the surface area and volume of specific buildings without considering connections to other concepts or problem-solving strategies. When encountering obstacles in problem-solving, these students often halt their solution process, preventing them from reaching a final result.

High-ability students exhibit a distinct approach to mathematical creative thinking compared to their peers. Their responses demonstrate a higher level of detail, particularly in terms of fluency and flexibility. However, not all indicators, especially elaboration and originality, are consistently reflected in their answers. Another notable finding is that while high-ability students often excel in fluency, some still struggle to demonstrate flexibility in solving creative thinking problems, hindering their ability to showcase creativity. However, a majority of creative-thinking students in the high mathematics ability category achieved level 3 (creative). This underscores the importance of providing students with open-ended questions to cultivate their ability to explore and express their thinking ideas. Effective teacher support in habituating students to such questions is crucial in nurturing well-patterned creative thinking.

Students with moderate mathematical ability demonstrate competence in understanding problems, designing alternative solutions, and formulating and implementing plans in problem-solving. However, when they encounter obstacles, some students, such as Shiva, exhibit a tendency to give up easily. As a result, the procedure described in their initial solution plan is often abandoned, affecting the overall problem-solving process. Students often give up easily when they encounter unanswered questions, interpreting them as too difficult. As a result, they prematurely end their attempts to find a solution without fully evaluating their solution plans or attempting to connect with other materials. Consequently, their answers lack diversity of ideas and details in solving creative thinking problems. Students in the moderate mathematical ability category exhibit a creative thinking level 1 (less creative) based on the analysis. While they demonstrate fluency in providing correct answers to some questions, they struggle to complete answers fluently for other questions. On the other hand, students with low mathematical ability can only demonstrate fluency, lacking flexibility, detail, and novelty in formulating solutions to mathematical creative thinking problems.

The results of mathematical creative thinking among students with moderate mathematical abilities showed limited diversity in responses, with answers being nearly identical and lacking detail. These students perceive creative thinking problems as challenging and similar to those faced by other students, resulting in difficulties in providing detailed and varied responses. During interviews, some students expressed feeling overwhelmed or challenged when confronted with unfamiliar problem-solving questions, describing them as 'hurting their heads.' This indicates that such questions are new and unfamiliar to students. However, their willingness to engage and attempt to find solutions suggests that with exposure and opportunities to explore such divergent questions, students' confidence in their mathematical creative thinking skills can develop over time.

The mathematical creative thinking process of low-ability students reveals significant challenges, including difficulty in interpreting known and unknown information in problems, predicting solutions, and verifying the correctness of answers. These students struggle to vary their responses, and their answers lack descriptive detail. As a result, they fail to demonstrate all three aspects of mathematical creative thinking, resulting in a creative thinking level of 0 (not creative).

Based on the results of students' mathematical creative thinking process and product, it is evident that changing students' problem-solving habits is not easy. Students are accustomed to routine questions with single solutions, making it challenging for them to adapt to questions requiring diverse answers. Introducing open-ended or divergent problems based on real-world scenarios is essential to foster habitual problem-solving skills in mathematics learning. Habitual practice can certainly hone students' creative thinking skills, leading to significant improvements over time. The research findings indicate that creative thinking in mathematics learning has not yet received adequate attention from teachers. The 2013 curriculum emphasizes the implementation of learning based on HOTS (Higher Order Thinking Skills), including creative thinking. Consequently, the questions presented should also reflect this focus on HOTS. (Tutiharati, 2022). This aligns with the belief that learning should enable students to explore and develop their creative thinking skills. However, these skills have not yet received sufficient attention from teachers (Sari &; Yunarti, 2015; Hanan &; Alim, 2023).

Today's math teachers need to prioritize students' creative thinking skills. By fostering these skills, students can learn to find diverse solutions and generate new ideas when faced with problems (Huliatunisa, et al., 2020). To develop creative thinking skills, students must be stimulated with non-routine questions in addition to the routine questions usually given by teachers. This aligns with Aizikovits' (2014) opinion that to stimulate creative thinking, students should be given difficult problems that require deep thinking rather than mere memorization of standard procedures. Such problems compel students to engage in more profound and innovative problem-solving (Aizikovitsh-Udi, 2014). This type of problem requires students to provide various solutions and solve the problem in multiple ways. Additionally, the learning process should actively involve students, allowing them to develop their own knowledge. If the learning process is dominated by the teacher, students are less likely to have the opportunity to build and discover knowledge independently.

The findings indicate that high-ability students possess a higher level of creative thinking compared to students with medium and low abilities. This aligns with the observed relationship between mathematical creative thinking and mathematical ability. Detailed levels of mathematical creative thinking for students with high, medium, and low mathematical abilities, along with the results from interviews, are presented in Table 1 below.

Table 1. Students' Level of Mathematical Creative Thinking in terms of Mathematical Ability

No	**Mathematical Ability**		**Creative Thinking Indicators**				**TKBM**	**Knot**
			Kl	Fl	Kt	Kb		
1	Tall	Carbo n copy	√	√	-	-	Level 3	Level 3 (Creative)
2	Keep	MD	√	-	-	-	Level 1	Level 1 (Less Creative)
3	Low	AND AND	-	-	-	-	Level 0	Level 0 (Not Creative)
4		D	-	-	-	-	Level 0	

Description: Kl: Smoothness, Fl: Flexibility, Kt: Detail, Kb: Novelty

Each student's creative thinking ability is demonstrated through their solutions to creative thinking problems, based on indicators of fluency, flexibility, and originality. These findings inform the description of each stage of students' levels of mathematical creative thinking (TKBM) when answering mathematical creative thinking problems.

1. Level 0 (Not Creative)

Students are categorized at level 0 (not creative) in mathematical creative thinking (TBKM) when they do not meet any indicators of mathematical creative thinking ability, such as fluency, flexibility, and originality. In this study, many students fall into the uncreative category. Below is an example of a level 0 (non-creative) response.

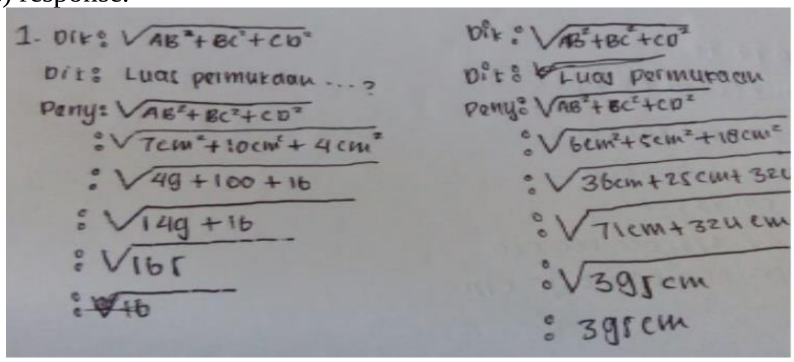

Figure 2. Student Response to Fluency Question

In Figure 1, the response from student SY illustrates their inability to correctly answer question 1, which involves calculating the surface area of a pentagonal prism using two different methods. The solutions provided by the student are incorrect and unrelated to the concept of the prism's surface area, resulting in none of the answers being accurate. Consequently, student SY does not meet the fluency indicator.

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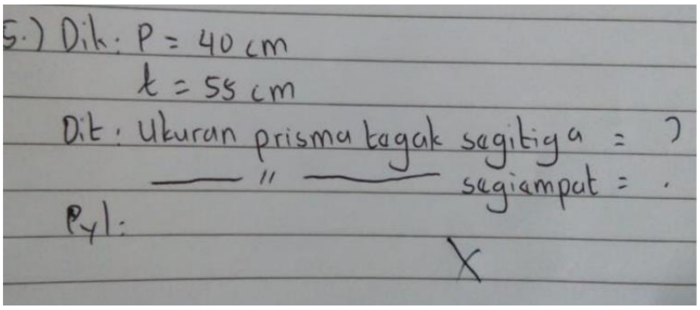

Figure 3. Student D's Response to the *Originality Question*

In Figure 3, student D's answer indicates a lack of understanding of the problem, resulting in an incorrect response. The student only records the length and height of the aquarium, overlooking other crucial information such as the volume of water, which is specified as 27,000 cm3. Question 4 pertains to an aquarium in the form of a quadrilateral prism, with students asked to determine the dimensions of prisms with the same volume but different shapes. Student D's response fails to present varied solutions or approaches and does not produce correct answers, nor does it demonstrate an unusual or innovative solution. Consequently, the student does not meet the indicators of originality in problem-solving (Andiyana et al., 2018).

All of the students' responses at the uncreative level exhibit a lack of ability to generate new solutions or ideas based on learned mathematical material when answering problems. This finding aligns with Siswono's assertion that students fail to achieve all indicators of creative thinking, placing them at level 0 (less creative).

2. Level 1 (Less Creative)

Students are categorized at level 1 (less creative) in mathematical creative thinking (TBKM) if they meet the fluency indicator, which entails providing answers in more than one way. At this level, students are only able to demonstrate fluency in their responses but do not meet the flexibility indicator and fail to provide unusual or new answers. Below are examples of student responses categorized at level 1 (less creative).

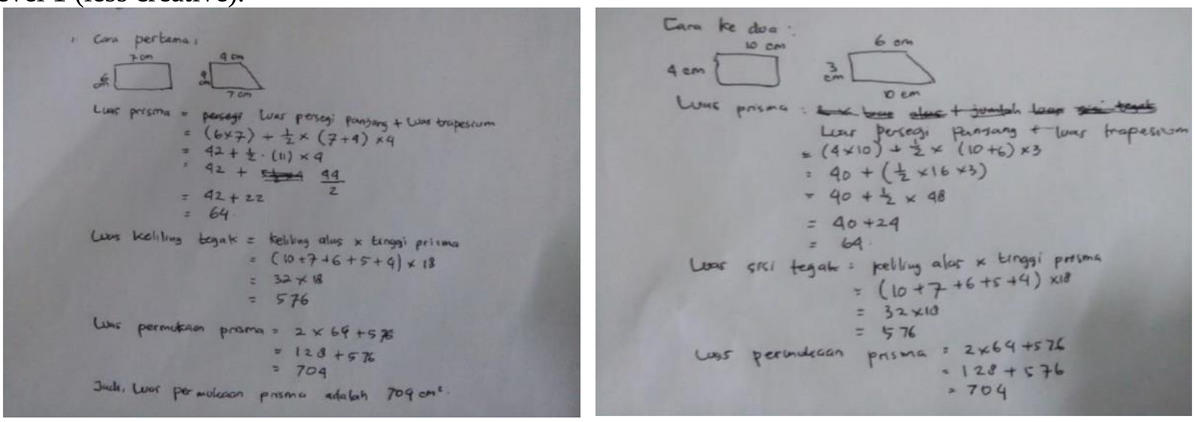

Figure 4. Student Response to *Flexibility*

In Figure 4, student MD demonstrates fluency in problem-solving by providing answers in two different ways to calculate the surface area of a pentagonal prism. By dividing the base into two areas—a square and a trapezoid—MD is able to obtain the surface area of the prism using unconventional methods. This approach showcases the student's ability to offer diverse solutions, thus meeting the fluency indicator. This finding aligns with Khamida's assertion that students who can generate varied solutions in mathematical creative thinking problems fulfill the fluency indicator.

Student MD encountered difficulty in solving question number 3, failing to provide a correct answer. The problem required flexibility, as students were presented with drawings and tasked with calculating the number of tiles needed to cover the pool wall given specific dimensions. During the preparation stage of the interview, student MD demonstrated a meticulous approach, carefully reading the questions and gathering information related to the problem. After gathering information, student MD attempted to relate it to their existing knowledge. However, they hesitated to complete the problem

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and continued pondering the solution. Subsequently, student MD ceased thinking about the problem altogether, feeling overwhelmed by its difficulty, and began daydreaming about unrelated matters (Pangestu &; Yunianta, 2019). Student MD's failure to continue their thought process and find solutions to the problem indicates a lack of flexibility. As a result, they did not meet the flexibility indicator.

3. Level 3 (Creative)

Students who reach level 3 (creative) in mathematical creative thinking demonstrate fluency and flexibility by showing two different ways to solve question number 1 and various solutions or ideas for question number 3. However, despite meeting the fluency and flexibility indicators, they may not provide an original solution, thus not meeting the novelty (originality) indicator. Three students achieved level 3 (creative) in this study. Their responses to the flexibility problem are presented in the following figure.

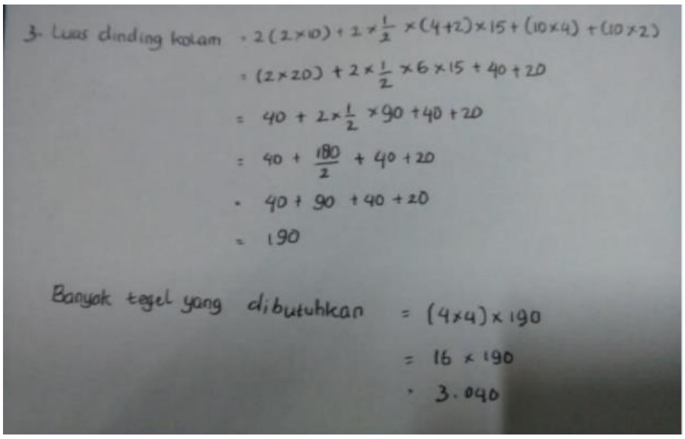

Figure 5. Student Responses to *Flexibility Questions*

In Figure 5, student DW's response correctly addresses the flexibility question, which involves calculating the number of tiles needed to cover the pool wall given specific dimensions. Student DW takes the step of calculating the area of the pool wall using an unconventional method, then determines the quantity of tiles required for coverage. This approach showcases student DW's ability to meet the flexibility indicators.

In answering question number 1, student DW demonstrates fluency by providing solutions in two different ways to determine the surface area of a pentagonal prism. This aligns with Andiyana's assertion that students who offer diverse solutions in mathematical creative thinking problems meet the fluency indicators. Consequently, based on student DW's responses to these two questions, they can be categorized as being at level 3 (creative).

Based on interviews with students at level 3 (creative) in creative thinking, it was revealed that preparation serves as the initial step in tackling problems. During this preparatory stage, students commence by thoroughly reading and comprehending the questions. They subsequently document their understanding of the questions and the known information, while also gathering additional information pertinent to the questions. After collecting relevant information related to the problem, students proceed to analyze known mathematical concepts. They then formulate ideas deemed suitable for solving the problem based on the requirements outlined. Rather than immediately diving into the problem, students contemplate the steps necessary to arrive at a solution. This process underscores the students' concerted effort and preparation in addressing mathematical creative thinking problems. This approach resonates with Sumartini's viewpoint, suggesting that students possessing proficient creative thinking skills can effectively comprehend problems, establish connections with previously acquired knowledge, and critically evaluate solutions to mathematical problems (Sumartini, 2019). In problem-solving, students draw upon mathematical concepts learned previously, enabling them to advance through the solving process and ultimately arrive at the final answer (Pangestu &; Yunianta, 2019) Subsequently, students engage in a critical review of their answers, beginning with an examination of the formula utilized, followed by an assessment of the steps undertaken in solving the problem, the calculation process, and ultimately, the derived final result.

4. Conclusion

In conclusion, the research findings reveal a significant correlation between mathematical ability and creative thinking skills among junior high school students. High-ability students demonstrate creative thinking, while medium-ability students exhibit less creativity, and low-ability students typically lack creative problem-solving skills, particularly in the context of surface area and volume problems. The dominance of students with low mathematical abilities underscores the importance of exploring each indicator and level of mathematical creative thinking. Furthermore, the development of diverse questions and teaching materials is essential to cultivate and enhance students' mathematical creative thinking skills.

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