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AN ANALYSIS OF STUDENTS' CREATIVE THINKING ERRORS IN SOLVING POLYHEDRA PROBLEMS

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ABSTRACT

Creative thinking skills are important in mathematics learning, especially in geometry, which requires students to generate ideas, choose alternative strategies, and construct flexible representations of spatial figures. However, students' creative abilities in polyhedra are still relatively low. This study aims to describe junior high school students' creative thinking errors in solving problems on flat-sided spatial figures based on indicators of fluency, flexibility, and originality. This study employed a qualitative descriptive approach. Initially, 35 ninth-grade students completed a creative thinking test on polyhedra problems, and three ninth-grade students who exhibited the highest number of errors were selected through purposive sampling for in-depth analysis. The research instrument was a creative thinking skill essay test with open-ended questions about polyhedra. The results showed that students' creative thinking abilities were in the low category, with fluency scores of 38%, flexibility scores of 32.5%, and originality scores of 21.7%. Qualitatively, students tended to produce similar container shapes, explored few variations in shape, and showed few truly new ideas. Students made mistakes in providing ideas, incorrectly converted information into solid elements, and wrote answers that could not be realized as three dimensional solids. Overall, the study concludes that students' creative thinking skills in solving polyhedra problems still require enhancement through learning strategies that promote idea exploration and foster a deeper understanding of polyhedral concepts.

Keywords: Creative thinking, polyhedra, fluency, flexibility, originality

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INTRODUCTION

Creative thinking skills are essential in 21st-century mathematics education. These skills enable students to generate diverse ideas, select alternative strategies, and develop solutions that are not confined to routine procedures. According to Hanifah et al. (2024), creative thinking in mathematics refers to students' ability to produce multiple ideas, shift strategies, and construct original solutions. In geometry topics such as polyhedra, creative thinking becomes even more crucial, as solving geometric problems requires the visualization of three-dimensional objects, an understanding of the relationships among their faces, and the ability to construct flexible net representations. Recent studies indicate that Indonesian students' mathematical creative thinking skills remain relatively low, particularly in the context of geometry (Safaria & Agus 2024). When dealing with problems related to polyhedra, students often struggle to generate varied ideas and solution pathways, making the enhancement of creative thinking skills in this area an important issue that requires further investigation.

In response to this situation, a more specific investigation into how students think when solving problems related to polyhedra is needed. Previous studies have shown that many students are able to recall formulas but experience difficulties in adapting them to the context of the problem or in developing alternative strategies when their initial approach fails (Hidayat & Sariningsih, 2018). This indicates that learning difficulties are not solely caused by limited conceptual understanding, but also by creative thinking processes that have not yet developed optimally (Siswono, 2011). Furthermore, research suggests that students need opportunities to express their ideas in more diverse forms, explore multiple solution pathways, and generate solutions that are not merely imitations of provided examples (Silver, 1997; Salsabila et al., 2024). Therefore, a deeper understanding of students' creative thinking processes is essential as a basis for designing learning activities on polyhedra that effectively foster students' creative abilities (Leikin & Pitta-Pantazi, 2013).

Several studies have reported that students experience difficulties in demonstrating creative thinking when solving geometry and polyhedra problems, particularly in terms of fluency, flexibility, and originality (Mawar et al., 2023; Gempur Anarky & Prastiwi, 2023; Syafira et al., 2023a). These studies indicate that students often generate limited solution ideas, rely heavily on visual spatial representations, and tend to imitate example-based strategies. However, most existing research primarily focuses on measuring students' levels of creative thinking ability rather than examining the specific types of creative thinking errors that occur during the problem-solving process. Consequently, there remains a lack of studies that systematically identify and analyze how such creative thinking errors emerge when students solve polyhedra related problems.

The novelty of this study lies in its focus, which not only evaluates students' creative thinking abilities but also analyzes their creative thinking errors based on the three main indicators proposed by Siswono (2011), namely fluency, flexibility, and originality. According to Sintawati and Asih Mardati (2023) Fluency refers to the number of acceptable responses. Flexibility refers to the number of different types of responses. Originality refers to how often responses are generated within a group. An indicator based analysis enables the identification of specific obstacles encountered by students, such as whether they fail to generate multiple ideas, fail to employ diverse strategies, or fail to produce solutions that differ from conventional responses. This approach is grounded in a mathematical creativity model that emphasizes the importance of viewing creativity as a process rather than merely as a product. By integrating the creativity indicators framework with the context of polyhedra, this study aims to produce a more comprehensive mapping of creative thinking errors than previous research.

Therefore, this study aims to: (1) describe the forms of students' creative thinking errors in solving polyhedra problems based on the indicators of fluency, flexibility, and originality; and (2) analyze in depth how these errors emerge within each indicator.

METHOD

This study employed a descriptive research method with a qualitative approach. According to Noor (2011), the descriptive method focuses on portraying reality as it is, without manipulating or intervening in the observed objects. Through this approach, the researcher seeks to provide a detailed, objective, and in depth description of the phenomenon under investigation. In this study, the main objective was to analyze students' errors in solving polyhedra problems based on indicators of creative thinking skills. The research was conducted at SMP Negeri 11 Kota Jambi with ninth-grade students, and the primary data consisted of students' written responses on the creative thinking test sheet. These data were then analyzed to identify errors based on the indicators of fluency, flexibility, and originality. The research population consisted of 35 ninth grade students, and the sample was selected using purposive sampling with the criterion of students who showed the highest number of errors in completing the test. From this process, three students were selected as the sample representing the most frequent errors for each indicator, allowing the researcher to conduct a more in depth analysis of the patterns of creative thinking errors demonstrated by the students.

The research instrument consisted of a single open ended question on polyhedra. This question was designed to measure students' mathematical creative thinking based on the indicators of fluency, flexibility, and originality, and had been validated by mathematics education experts. The three indicators and their corresponding assessment descriptors are presented in Table 1.

Table 1. Characteristics of Creative Thinking Indicators in the Test Items

No	Creative Thinking Indicators	Description
1.	Fluency	Students must be able to generate multiple ideas for possible containers, present various options for relevant shapes and sizes, and demonstrate fluency in producing a range of alternative solutions within a given time frame.
2.	Flexibility	Students must demonstrate a range of approaches and strategic shifts in using cardboard to create containers that vary in shape, structure, and the procedures applied in assembling or lining the containers..
3.	Originality	Students must generate ideas for containers that are uncommon, distinct from typical designs, rarely considered by other students, and characterized by unique shapes or functions.

The students' answers were subsequently scored and analyzed based on the indicators of creative thinking skills. The calculation of students' creative thinking scores for each indicator fluency, flexibility, and originality was carried out using the following formula:

$$\boxed{\text{Score} = \frac{A}{B} \times 100}$$

Source: (Hidayati Arifani & Setiawani, 2021)

Description:
$A =$ total score obtained by the students for each indicator
$B =$ maximum score for each indicator

The students' assessment results were derived from scores assigned using an assessment rubric based on indicators of creative thinking. For each indicator, the minimum score for an individual students was zero and the maximum score was three. As the assessment involved 35 students, the maximum possible score for each indicator was 105, obtained from the accumulation of the maximum individual scores of all students. The obtained scores were then categorized according to the levels of creative thinking ability.

After all information from the various data collection techniques was gathered, the next step was to analyze the data. The data analysis technique used in this study followed Miles and Huberman's qualitative analysis model (Sugiyono, 2019), which consists of three stages: data reduction, data display, and conclusion drawing. In the data reduction stage, the researcher organized the data, removed irrelevant information, and summarized the results of the tests to ensure that the data remained aligned with the research objectives. In the data display stage, the reduced data were rearranged and presented clearly and systematically to facilitate the interpretation process. The data were displayed in an appropriate narrative form. Finally, in the conclusion drawing stage, the researcher formulated the essential findings from the presented data using concise and clear statements. This stage produced the overall conclusions of the study.

RESULT

This study involved collecting data from students' creative thinking ability tests presented as spatial tasks. Scores were assigned to students' responses for each item according to the indicators they achieved. The total score for each question was then calculated based on the targeted indicators. To determine the average and percentage of students' creative thinking abilities for each indicator, the students' responses were analyzed by calculating the percentage of the average score obtained. The results were then interpreted according to each indicator. This study used creative thinking indicators adapted from (Siswono, 2011).

After the students completed the written test, their responses were scored and analyzed based on the creative thinking indicators. The results of the students' creative thinking abilities are presented in Table 2.

Table 2. Percentage of Students' Creative Thinking

Creative Thinking Indicators	Maximum Score	Mean Score	Percentage
Fluency	105	40	38%
Flexibility	105	34.2	32.5%
Originality	105	22.8	21.7%

Based on the data presented in Table 2, the percentages for all creative thinking indicators remained below 50%. The most striking result is that the score achieved on the originality indicator was only 21.7%. This indicates that most students were unable to produce solutions that differed from those of their peers and tended to provide routine or conventional responses. In addition, the low achievement on the fluency indicator (38%) and the flexibility indicator (32.5%) suggests that students had difficulty generating ideas effectively and were unable to apply a variety of strategies in solving the problems.

The assessment results indicate that students' creative thinking skills remain low across the indicators of fluency, flexibility, and originality. This finding suggests that students experience difficulties in solving problems that demand creative thinking. To further identify the sources of these difficulties, an error analysis was conducted based on each creative thinking indicator to determine the areas in which students most frequently made mistakes.

Based on these findings, the subsequent step is to examine in greater detail how these errors emerge in students' responses to each test item. This analysis focuses on the students' written work and explanations to clearly identify discrepancies between their responses and the criteria of the creative thinking indicators. Accordingly, the following section presents an in-depth analysis of students' answers beginning with Subject 1 to identify recurring error patterns related to fluency, flexibility, and originality as defined in the test. Through this analysis, the students' weaknesses in generating ideas and constructing solutions can be understood more concretely.

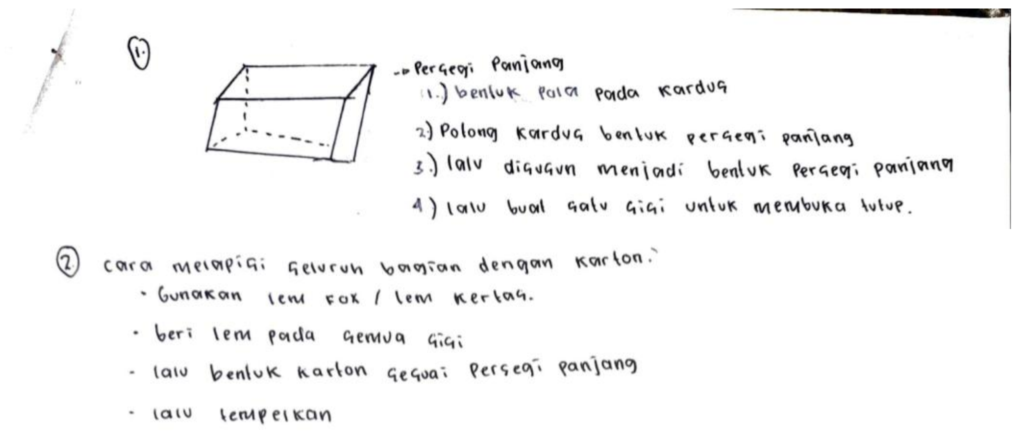

Figure 1. Subject 1's Answers in the Test

Based on subject 1's response, it appears that the students produced only one container design using rectangular cardboard pieces, even though the task explicitly required students to create "more than one design or draft of a new container shape." In the context of polyhedra, the fluency indicator requires students to generate multiple ideas, such as several possible nets, different methods for assembling the sides, or various alternatives for cardboard sizes and orientations. However, the students provided only a single, simple block design accompanied by linear procedural steps, such as cutting the cardboard, forming rectangular pieces, and attaching the sides to create an opening. Even in designing the block shape, the students failed to produce a representation that aligned with the concept of spatial construction, as indicated by the incorrect depiction and incomplete structural details. Furthermore, the students did not propose any additional variations that could have been created from the available rectangular cardboard pieces. This finding indicates that the students was unable to utilize the provided materials to explore multiple alternative solutions. Thus, the error in the fluency indicator lies in the students's inability to generate a sufficient number of ideas both in terms of container design and in outlining the steps for assembling and lining the container using the given cardboard pieces.

In relation to the flexibility indicator, the students appeared to rely on only a single type of representation namely a cuboid illustration accompanied by a rigid procedural sequence. In contrast, the task required students to explain how the cardboard should be assembled, cut, and folded into a container that corresponded to their intended design. The students did not demonstrate the ability to shift strategies, such as by presenting alternative sketches of nets, employing calculations to determine surface dimensions, or considering different methods for assembling the container. The steps provided were predominantly procedural and suggested mere imitation of basic actions such as cutting and gluing, without exploring other possible approaches, including designing folding patterns, determining proportional relationships among the faces, or visualizing the three-dimensional structure through two-dimensional representations prior to construction.

The absence of varied strategies indicates that the students had not yet developed sufficient flexibility in approaching problems involving flat-sided spatial figures. Errors associated with this indicator were evident in the student's reliance on the simplest, most straightforward strategy without recognizing that the task allowed for multiple solution pathways. Ideally, constructing a spatial figure requires considering the essential elements and structural relationships of the solid to generate an appropriate form. However, this was not reflected in students 1's response, resulting in an answer that did not fulfill the requirements of the task.

The originality indicator in this task is reflected in students' ability to propose novel container designs, vary the use of available cardboard sizes, and generate solutions that deviate from common or conventional patterns. However, the students' responses only presented rectangular container designs with simple lids, without any variation in form, folding mechanisms, or structural features. The procedures described were similarly conventional—limited to cutting and gluing cardboard and did not demonstrate any innovation in the design process, the mechanism for closing the container, or the utilization of spatial construction principles. Even the steps related to covering the exterior of the container were not relevant to the concept of spatial structures and did not reflect the production of new ideas. Consequently, the solutions provided do not fulfill the originality indicator, as the ideas remain standard and lack creative distinction.

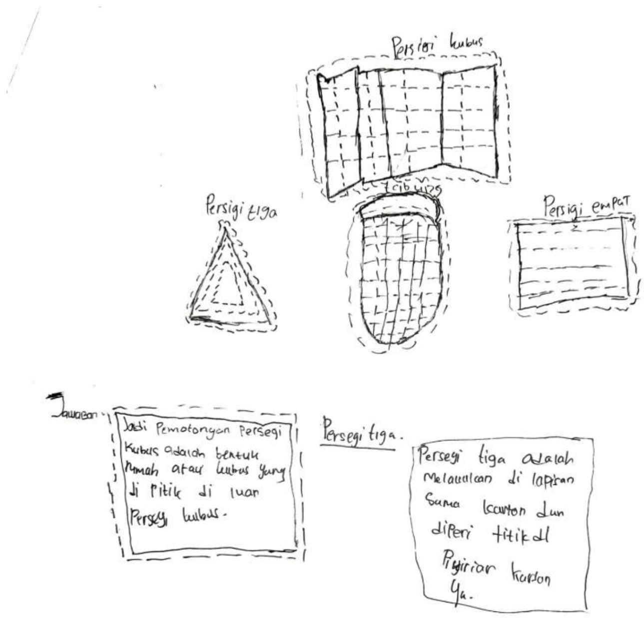

Figure 2. Subject 2's Answers in the Test

The students's answer indicates that they have not yet demonstrated the creative thinking processes required by the task. In terms of fluency, the students did produce several drawings such as a "cube," a "triangle," and a "square" however, none of these shapes are relevant to the actual objective of the problem, which is to design a flat-sided net for constructing a closed container. Although multiple ideas appeared, they did not contribute to an appropriate or feasible solution. Furthermore, the students did not provide systematic steps or logical explanations regarding how the net should be folded or assembled into a solid figure. This shows that the students's fluency is still low, as they were unable to generate correct, coherent, and contextually appropriate ideas.

In terms of flexibility, the students did not demonstrate the ability to apply diverse or adaptive strategies in solving the problem. Although the students produced several variations of shapes such as triangles, squares, and ellipses these representations were not relevant to the construction of a spatial net, which requires interconnected planar faces that can be folded into a three-dimensional figure. The students's inability to shift from drawing unrelated shapes to attempting the formation of a proper net indicates a lack of conceptual understanding of flexible thinking within the context of spatial geometry.

In terms of originality, the students's response indeed differs from those of their peers, particularly because the shapes drawn are uncommon within the framework of spatial net construction. Nevertheless, such distinctiveness cannot be classified as positive originality, as the ideas presented are not aligned with the mathematical objectives assessed in the task. Originality in creative thinking should not merely reflect deviation from other students' work, but must also yield purposeful and contextually appropriate ideas that contribute to problem solving. In this case, the students's representations instead reveal conceptual misunderstandings, indicating that the originality criterion has not been fulfilled. Overall, the three indicators of creative thinking are not sufficiently demonstrated, as the ideas, strategies, and representations employed do not lead toward a valid solution to the geometric problem.

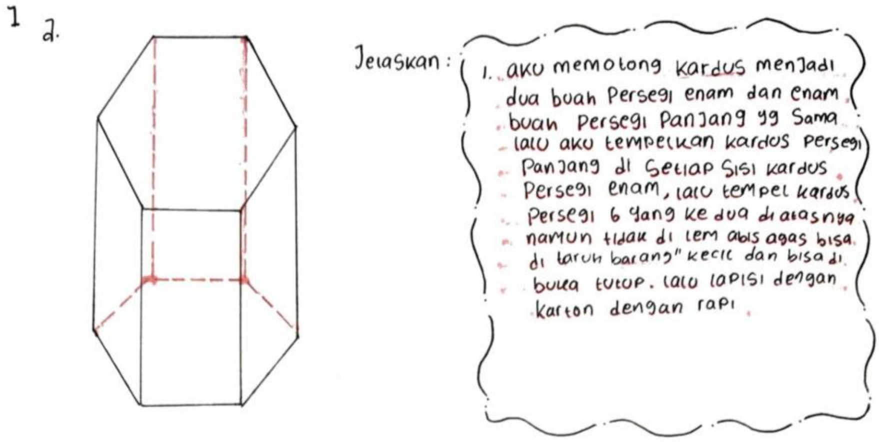

Figure 2. Subject 3's Answers in the Test

On the fluency indicator, the students produced only a single container design and one corresponding net, despite the task explicitly requiring the creation of "more than one design or new container shape." Although the design incorporated hexagonal components, the students did not provide additional alternatives or variations in form. The written explanation similarly presented only one procedural sequence, without elaborating on alternative techniques, orientations, or potential configurations of the available cardboard pieces. These observations indicate that the students has not yet demonstrated the capacity to generate multiple and diverse ideas, and therefore the fluency indicator has not been fulfilled.

The students did not demonstrate flexibility in thinking when explaining the construction of the container. The response relied solely on one form of representation a single grid pattern and followed a strictly procedural approach. The students did not explore alternative strategies, such as utilizing different cardboard cutouts, experimenting with other folding configurations, or creating variations in the container's lid design. Although the use of a hexagonal shape reflects some creativity, the overall arrangement adhered to a single strategy and did not exhibit adaptability in approach. Consequently, the flexibility indicator has not been fulfilled, and the students's strategy continues to show deficiencies in flexible problem-solving.

Although the nets created by the students using hexagonal shapes were distinctive compared to their peers' responses, indicating potential originality, this originality was not fully realized. The incomplete implementation of the idea, specifically the lack of a correct and detailed explanation regarding how to coat the exterior of the container meant that the unique design was not supported by a functional, neat, or aesthetically appropriate finishing process. Originality in creative thinking is not solely determined by the emergence of different ideas but also by the ability to execute them thoroughly. Since the coating and finishing procedures were neither properly described nor implemented, the originality indicator cannot be considered fully achieved. While the idea shows elements of novelty, it remains incomplete and has not been effectively actualized.

DISCUSSION

The analysis of subject 1's, subject 2's, and subject 3's responses shows that students experienced significant difficulties in all three indicators of creative thinking—fluency, flexibility, and originality—when solving problems related to polyhedra. These findings align with recent studies in mathematics education, which consistently report that students often struggle to demonstrate creative thinking in geometry tasks that require spatial construction and the generation of multiple solution ideas. Syafira et al (2023b) found that most students were only able to meet part of the creative thinking indicators and tended to produce only a single representation when solving open-ended problems involving polyhedra.

For the fluency indicator, subject 1 and subject 3 generated only one container design even though the task required more than one alternative. Subject 2 was able to produce more than one answer, but the answers given were irrelevant and inappropriate, thus failing to meet the fluency indicator. This result is consistent with the findings of Valeska et al. (2022), who reported that students frequently rely on a single net or spatial representation without exploring other possibilities. Such patterns indicate limitations in producing multiple ideas and reflect low fluency in creative thinking within the context of constructing polyhedra.

For the flexibility indicator, the students did not demonstrate any variation in strategy, representation, or approach. The responses consisted solely of a simple cuboid illustration accompanied by linear procedural steps. The absence of alternative nets, folding patterns, measurement-based reasoning, or other solution pathways mirrors the findings of Dintarini et al. (2022), who noted that many students exhibit low spatial flexibility because they rarely use varied representations or strategies when solving geometric problems.

The analysis of originality also shows that the students failed to produce innovative or unconventional ideas. The designs created were standard rectangular containers without variations in structure, folding mechanisms, or the creative use of available cardboard sizes. This finding is in line with research by Salsabila et al. (2024), which revealed that junior high school students commonly produce conventional designs and rarely demonstrate original or unique ideas in polyhedron construction tasks. Elsa et al. (2022) similarly reported that many students simply imitate familiar patterns rather than developing new structural ideas in three-dimensional geometry.

Beyond creative thinking errors, the pattern of responses also reflects conceptual and procedural misunderstandings related to polyhedra. This is supported by Yuniar et al. (2025), who showed that students often misinterpret geometric information and struggle to translate two-dimensional representations into complete and accurate three-dimensional forms.

Overall, these findings suggest that students' low creative thinking abilities are closely linked not only to their limited idea generation but also to weak spatial reasoning, insufficient conceptual understanding, and minimal exposure to varied problem-solving strategies. Consistent with recent literature, enhancing these abilities requires learning designs that incorporate open-ended tasks, multiple representations of nets, hands-on construction experiences, and integrated technological or manipulative tools to strengthen students' understanding of polyhedral structures.

CONCLUSION AND SUGGESTIONS

The results of the study show that students' creative thinking skills in solving flat-sided spatial problems are still low and marked by various errors that arise in the problem-solving process. When assessed based on creative thinking indicators, students' fluency skills are still limited, with an achievement of 38% of the maximum score, indicating a lack of alternative ideas or variations in the shapes of containers produced. Their flexibility skills are also not optimally developed, only reaching 32.5%, as seen from the student's' inability to change strategies or see other possible shapes when the initial strategy does not work. In terms of originality, the students' achievement is even lower, at 21.7%, which shows that most students are not yet able to produce unique and mathematically relevant solutions, i.e., answers that appear visually different often cannot be realized as correct spatial nets. Thus, students' errors are not only procedural in nature but are also closely related to the underdevelopment of creative thinking skills in understanding and representing flat-sided spatial concepts. Differences in ability between students are also clearly evident, as students with higher creative scores still show errors in representation, while students with low creative scores experience errors from the problem-understanding stage.

Overall, this study confirms that creative thinking skills and geometric understanding are closely related in solving polyhedron problems. Error analysis based on creative thinking indicators, namely fluency, flexibility, and originality, allows for a more detailed identification of students' points of failure. These findings provide a basis for teachers to design learning activities that encourage idea exploration, strategy variation, and the development of more flexible geometric representations. This study makes an important contribution to mapping students' creative thinking barriers in solving problems related to the concept of polyhedra. However, this study has limitations in that the number of subjects analyzed in depth only involved three students, so the findings cannot be generalized more broadly. In addition, the use of a single instrument in the form of a written test meant that students' thinking processes were not fully explored. Future research should involve more subjects and utilize additional instruments such as interviews or thinking observations to provide a more comprehensive picture of students' creative thinking processes and errors.

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