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Students' Creative Thinking in Solving Integrated Mathematical Problems Cultural Context Reviewed Based on Specialization

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ABSTRACT

Creativity in mathematics is essential for developing students' problem-solving skills and innovation, yet in Indonesia, students' creative thinking remains low, as shown by PISA and TIMSS results, indicating a significant gap between expectations and current practices in mathematics learning. To address this issue, this study aimed to analyze the creative thinking characteristics of Grade IX students when solving culturally integrated mathematical problems, while also considering differences among student specialization groups: Mathematics, Science (IPA), and Social Studies (IPS). The research employed a qualitative case study design involving 30 students from a junior high school in Malang City during the 2024/2025 academic year. Based on a creative thinking test, 15 students (6 mathematics, 5 science, and 4 social studies specialization) were selected for in-depth interviews. Data were analyzed through several stages: preparation, coding, categorization, presentation of findings, interpretation, and validation. The findings revealed distinct creative thinking characteristics across the three groups. Mathematics specialization students demonstrated strong fluency through generating many ideas, filtering logical ideas, and responding quickly; flexibility through diverse approaches and adaptability; and originality through expressing unique and innovative solutions. Science specialization students showed similar traits in fluency and flexibility, with originality evident in their ability to create and articulate unique ideas. Social studies specialization students demonstrated fluency and flexibility but lacked originality characteristics. These results highlight variations in creative thinking profiles among different specialization groups and emphasize the importance of targeted instructional strategies to foster creativity in mathematics education.

Keywords: creative thinking; cultural contexts; mathematical problems; specializations

INTRODUCTION

Creativity in mathematics emphasizes the process of generating original, aesthetic, and constructive ideas (Quaye et al., 2023). The ability to think creatively has become one of the essential competencies in 21st-century learning (Rahayu et al., 2022) because it equips students to face complex global challenges and to develop innovative solutions. According to Hadar & Tirosh (2019), creative thinking plays a vital role in mathematical problem-solving and in generating new ideas, while Auliyah et al (2021) highlight that creative thinking involves the skill to analyze new information and combine unique ideas to form meaningful solutions. Therefore, creative thinking is considered a foundation for fostering innovation and adaptability in learning (Miller & Dumford, 2015).

However, various international assessments indicate that Indonesian students' mathematical and creative thinking abilities are still relatively low. Based on the 2022 Programme for International Student Assessment (PISA) by the OECD, Indonesian students' average mathematics score decreased from 379 in 2018 to 366 in 2022. This result reflects that although ranking improvements occurred, the absolute performance in mathematical reasoning and problem-solving has not yet shown significant progress. Likewise, the 2023 Trends in International Mathematics and Science Study (TIMSS) reaffirmed that Indonesian students are still behind their international peers in applying reasoning and creative problem-solving. These findings reveal that the mathematics learning process in Indonesia has not yet optimally fostered students' creative thinking skills.

In the classroom context, students are often given routine problems that emphasize procedural accuracy rather than exploration and originality. As a result, they rarely have opportunities to express multiple or unique solutions (Ermayani et al., 2023). Even students categorized as having high mathematical ability often fail to demonstrate complete creative thinking indicators (Lupa et al., 2023). This condition reflects that learning activities and assessments have not yet been designed to cultivate creativity. In several junior high schools in Malang City, for instance, students rarely encounter mathematical problems that encourage creative exploration, while teachers are still limited in designing learning experiences that meaningfully integrate creativity.

Previous studies have attempted to enhance students' creative thinking through various learning models. For instance, Vistara et al (2022) found that STEM-oriented Problem-Based Learning (PBL) could improve students' creative thinking, while Wulandari et al (2021) revealed that the guided inquiry model positively affected students' creative thinking processes. Recent research also highlights the role of cultural integration in mathematics learning through ethnomathematics. According to Aisyah et al (2024) and Korianto et al., (2024), learning that integrates cultural contexts significantly increases students' creative thinking skills. Similarly, Anwar et al (2024) state that integrating mathematics with cultural elements helps students better understand concepts and relate them to everyday life. However, Mei et al (2025) noted that creative thinking outcomes in ethnomathematics-based learning have not consistently shown significant results, indicating the need for further exploration.

In this study, the cultural context refers to local traditions, practices, and artifacts familiar to students. Integrating these cultural elements aims to make learning more meaningful and to encourage students to connect abstract concepts with real life experiences. This approach not only strengthens conceptual understanding but also stimulates creativity by encouraging students to think flexibly, generate multiple solutions, and express originality in problem-solving.

Based on a preliminary study conducted by the researcher, students demonstrated varied creative thinking profiles across different specializations (Mathematics, Science, and Social Studies). Some students only met one indicator of creative thinking (fluency, flexibility, or originality), while others achieved two indicators simultaneously. This suggests potential differences in creative thinking characteristics based on specialization, which have not been widely examined in previous research.

Therefore, this study aimed to analyze the creative thinking characteristics of Grade IX students when solving culturally integrated mathematical problems, while also considering differences among student specialization groups: Mathematics, Science (IPA), and Social Studies (IPS). Through this approach, the research seeks to provide insights into how cultural integration can enhance creative thinking in mathematics learning and reveal distinctive thinking patterns among students with different academic specializations.

RESEARCH METHODS

Research Design

This study used a qualitative case study design to explore in depth the creative thinking processes of Grade IX junior high school students when solving problems related to three-dimensional geometry. The case is defined as the creative thinking demonstrated by a class of 30 students divided into three specialization groups: Mathematics, Natural Sciences (IPA), and Social Sciences (IPS), based on a diagnostic test conducted by the school. A case study was chosen because it allows researchers to investigate this phenomenon within its real-life classroom context, providing a holistic understanding of students’ problem-solving strategies.

Research Setting and Participants

This study was conducted at a public junior high school (SMP) in Malang City, East Java, Indonesia, during the even semester of the 2024/2025 academic year in March 2025. The research subjects were students in Grade IX, subdivided in three separate streams: mathematics, natural sciences (IPA), and social sciences (IPS). Each group contained ten students, a composition decided by the school after the results of the beginning of year diagnostic test. All 30 students were given a single open ended, creative thinking problem devised to research three levels of creative thinking: fluency, flexibility, and originality. They each received 30 minutes of individual time to work on the problem. From the variety and level of aspects of creative thinking exhibited, respondents’ responses and communication clarity, 15 students were selected for follow up interviews: 6 from the Mathematics group, 5 from IPA, and 4 from IPS. The interviews were conducted individually, each lasting 30 minutes, a day after the test to provide further clarification on students’ answers while analyzing the creative problem solving steps in order to understand it on a much deeper level.

Research Instruments

In this study, the test questions used were descriptive questions, requiring students to write down the complete steps of the task until they reach the final result. The test instrument served to obtain data on students' creative thinking characteristics in solving open-ended problems on the topic of geometric shapes. The test questions used had undergone a validation process by a validator, thus making them suitable for use in research. The type of validation chosen by the researcher was expert validation, which was reviewed based on language suitability, suitability to the research objectives, and suitability to the construction.

Data Collection

The data were collected from two primary sources: the students’ written responses and the transcripts of the interviews. The written responses exhibited the students’ preliminary levels of creativity in arriving at problem solving answers, while the interviews captured their reflective thinking as well as their thought processes. The integration of multiple data sources is consistent with the tenets of case study research, as it permits triangulation, and ultimately, a richer appreciation of the case.

Data Analysis

Data analysis was done following a systematic and qualitative process of analysis as put forth by Miles et al. (2014). First, all data such as students' answers and transcript of the interviews were collected and structured aiming to prepare them for the process of analysis. The data was anonymized as each of the participants was coded to ensure confidentiality. Following this, key ideas, patterns, and strategies were captured in the process of open coding. The coding was done based on the three indicators of creative thinking, which are fluency, flexibility, and originality. For example, the attribution of the code fluency included responses containing multiple solutions to a problem, while ideas that were new and different were attributed the code originality. The codes were grouped in broader categories based on constant comparison, leading to the construction of themes which explained the ways through which the students engaged in creative problem-solving. The results were structured in a narrative outlined as reports where distinct pieces of students' work as well as interviews supported the narratives and the analyses of the narratives were linked with theories and other works done before them. In this case, data source triangulation and member checking with participants were done to ensure credible results.

Ethical Considerations

Ethical approval was obtained from the relevant institutional review board and the participating school. Students and their guardians were informed about the objectives and procedures of the study, and written consent was secured before participation. All participants were assured of the confidentiality and anonymity of their data. Pseudonyms were used in reporting the results to protect students' identities, and participation was entirely voluntary, with the option to withdraw at any time.

RESULTS AND DISCUSSION

The results of the study by providing a creative thinking test for students with an integrated cultural context in grade IX of one of the junior high schools in Malang City on March 11 until 13, 2025 on 30 students: 10 students with a specialization in mathematics, 10 students specializing in science, and 10 students specializing in social studies are presented in the following table.

Table 1. Results of Students' Creative Thinking Percentage

No	Specialization	Creative Thinking Indicators	Percentage
1	Mathematics Specialization	*Fluency*	50% dari 10 siswa
		Flexibility	50% dari 10 siswa
		Originality	30% dari 10 siswa
2	Science Specialization	*Fluency*	60% dari 10 siswa
		Flexibility	30% dari 10 siswa
		Originality	10% dari 10 siswa
3	Social Studies Specialization	*Fluency*	40% dari 10 siswa
		Flexibility	20% dari 10 siswa
		Originality	0% dari 10 siswa

From the 30 students who completed the creative thinking test, 15 participants were selected for interviews and in-depth analysis based on criteria such as diversity and completeness of creative thinking aspects, clarity of written responses, communication skills, and willingness to participate. These 15 students were distributed across the three specialization groups as follows: Mathematics group – 3 students representing fluency, 2 students representing flexibility, and 1 student representing originality; Science (IPA) group – 2 students representing fluency, 2 students representing flexibility, and 1 student representing originality; and Social Sciences (IPS) group – 2 students representing fluency and 2 students representing flexibility, with no students representing originality. Among these, one key representative from each specialization group and each creative thinking aspect was highlighted to illustrate the findings:

Table 2. Selection of Research Subjects

No	Specialization	Creative Thinking Indicators	Subject Identity
1	Mathematics Specialization	*Fluency*	FL 1
		Flexibility	FE 1
		Originality	FO 1
2	Science Specialization	*Fluency*	FL 2
		Flexibility	FE 2
		Originality	FO 2
3	Social Studies Specialization	*Fluency*	FL 3
		Flexibility	FE 3
		Originality	-

Description of Creative Thinking Characteristics of Mathematics Specialization Students

Fluency

In the fluency indicator, there are 5 subjects that show fluency creative thinking skills or students' ability to produce a variety of solutions oriented to 1 concept. Based on the results of the identification that has been carried out, there are 4 general characteristics or characteristics of subjects who have the ability to think creatively fluently in mathematics specialization.

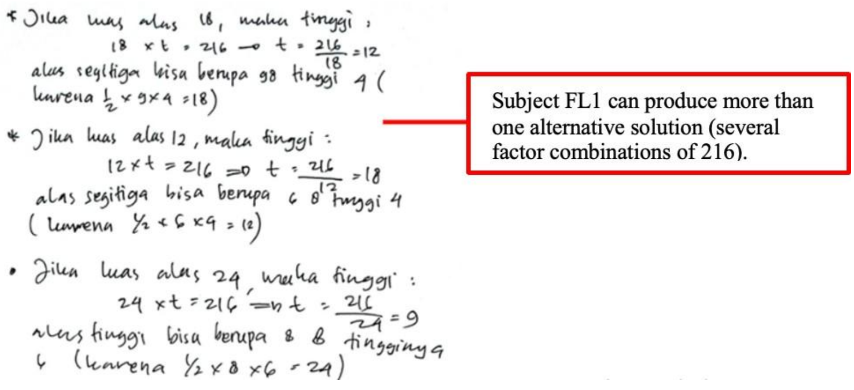

Figure 1. FL 1 Subject Answers

Generate a lot of ideas

When solving the problem of converting the block-shaped 216 cm^3 altar volume into a flat side space building other than the beams and cubes, the subject of FL 1 is able to present three different alternatives. The three alternatives are shown through variations in the values of the area of the triangular base and the height of the prism. Subject FL 1 transforms to a triangular prism shape and looks for a multiplication pair that yields 216 cm^3. Based on the results of the interviews that have been conducted, the subject of FL 1 found multiplication pairs such as 18 x 12.24 x 9, and 12 x 18. Then, the factors that had been found by the subject FL 1, were substituted into the formula of the triangular prism volume (base area x height) and it was proven that all the factors obtained produced a fixed volume of 216 cm^3. In line with research from Rahayuningsih et al (2021) which shows that students with creative thinking skills are able to produce various alternative solutions in open mathematics problems, so that the variety of ideas is an important indicator to measure the level of fluency. This is also in line with the findings of Widyaningsih et al (2024) that students' success in generating many ideas is related to their skills in exploring mathematical concepts.

Have Fluency in Thinking

Referring to the picture of the subject's answer results, it can be identified that the subject performs precise and smooth calculations based on the relevant formula. In addition, the written answer presentation is arranged in a concise and clear manner. This shows that students' schools of thought are relatively active and flexible. In addition, in the process of work, the subject is relatively fast in solving the questions presented. This speed is certainly supported by the subject's fluency in thinking. The results of interviews with the subjects showed that, in the process the subjects tried several possible factors that met and thought that the fixed volume of the block had other possible sizes. In the context of calculations carried out to solve problems of culturally integrated creative thinking, students bring up fluency in thinking which is shown through detailed calculations and the speed of time in the process (Shafa et al., 2023). This ability also reflects a logical and systematic thinking style, which is one of the characteristics of students majoring in mathematics. This finding is in line with the research of Schulz (2024) which states that students' fluency in thinking is characterized by a systematic completion flow and the use of relevant formulas. Similar research by Chen (2024) also confirms that fluency in thinking plays a big role in accelerating the process of solving mathematical problems because students can connect information quickly and precisely.

Filtering Logical Ideas

Another characteristic that appears on the fluency indicator is the subject's ability to filter logical ideas. Based on the results of the interview, the subject revealed that in his work he considered the logic and proportional size of the answer. This is intended so that the size is not strange. The results of the subject's answers can be interpreted that the subject is not only able to explore various ideas, but also able to control the ideas to keep them reasonable and proportional. Students also do not just accept all possible sizes, but also filter and evaluate whether they make sense and fit the context. This is shown at the work stage, students pay attention to the proportionality between the size of the building. A study from Schulz (2024) confirms that the ability to filter logical ideas is an important part of the fluency indicator because students must ensure their answers are consistent with mathematical logic.

Respond Quickly

Another characteristic that appears in the fluency aspect in mathematics specialization is the subject's ability to respond to problems quickly. This is shown through the end time, subjects who meet the fluency aspect are completed faster than subjects who meet other aspects. Students who meet these characteristics, have an average of less than 20 minutes of work. This shows that students with fluency skills are considered faster in responding to problems than students with other creative thinking skills. The character of mathematics students who tend to have high enthusiasm when facing mathematics problems also strengthens the emergence of this fluency of thinking (Anh & Duong, 2023). This can be seen from how students can quickly and in detail describe the calculation steps in solving problems that demand their creativity.

Flexibility

In the flexibility indicator, there are 5 subjects that show the ability to think creatively, flexibility, or students' ability to produce a variety of strategies. Based on the results of the identification that has been carried out, there are 2 general characteristics or characteristics of subjects who have the ability to think creatively and flexibly.

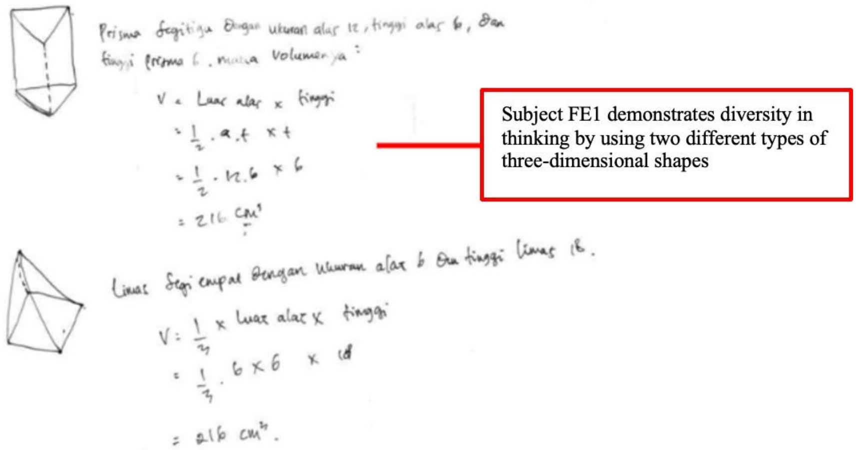

Figure 2. FE 1 Subject Answers

Showing Diversity of Thinking

One of the characteristics that appears in this indicator is the ability of the subject to show the diversity of his thinking. This is shown in the subject's answer that is able to transform a block-shaped altar into another flat-sided room with a different type, namely a triangular prism and a quadrilateral prism. Based on the results of the interviews conducted, the subjects changed to the shape of a triangular prism and a rectangular prism because of their familiar shape. This is in line with research by Syam (2020) which found that students with the ability to think flexibility can use a variety of strategies in solving math problems. Research by Morin & Herman (2022) also shows that diversity of thinking helps students see problems from different perspectives, resulting in more than one form of solution representation. With the ability to think logically and systematically that is the characteristic of mathematics students, the diversity of approaches they produce is not just random, but through rational and contextual considerations (Kunisch et al., 2023).

The Ability to Move from One Approach to Another

Based on the subject's answers, namely two different types of flat side space building in the form of a triangular prism with a triangular base size of 12 cm, a triangular height of 6 cm, and a prism height of 6 cm and a rectangular flat side space with a base size of 6x6 cm and a height of 18 cm. Subject FE 1 understands that the shape and formula used in the two flat-sided space buildings are different. However, both are adjusted in size to produce the same volume. This shows that FE 1 subjects have the ability to explore ideas by moving from one approach to another, so that they are not just oriented to 1 concept. This is supported by the results of the interview that the subject believes that a volume can not only be achieved in one way, but can be used in another. These findings are in line with the research of Stein et al (2018) which states that the ability to move from one strategy to another reflects students' cognitive flexibility. In addition, (Shafa et al., 2023) research revealed that students who are able to switch approaches tend to be more adaptive to variations in math problems so that their creativity develops. This ability is in line with the theory of creative thinking by Krulik & Rudnick (1995) which reveals that flexibility in creative thinking is interpreted as the ability of students to consider various possibilities and adjust their approach.

Originality

In the originality indicator, there are 3 subjects that show creative thinking skills, originality, students' ability to create unique ideas. Based on the results of the identification that has been carried out, there are 3 general characteristics or characteristics of subjects who have the ability to think creatively originally.

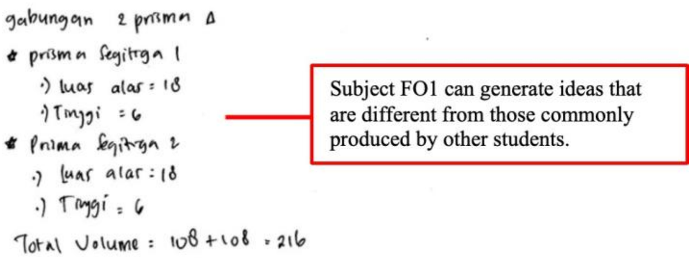

Figure 3. FO 1 Subject Answers

Dare to try out a unique idea

This characteristic is the main characteristic that is needed to bring out the aspect of originality. This is because students' courage to try unique ideas provides opportunities to generate unique ideas. In this case, students have the courage to take risks in finding unique solutions. Based on the results of students' answers which show that the results of the ideas that emerge are the output of courage in trying unique ideas. In line with Yaniawati et al (2020) research which found that students' courage to try new ideas greatly influences the emergence of originality aspects in creative thinking. Similar results were stated by Wan et al (2021) that students who dare to take intellectual risks are more able to produce different solutions than students who tend to be conventional. This kind of ability is very likely to arise because students are enthusiastic about facing problems so that they are encouraged to display their best ideas in a more creative and challenging form (Kardoyo et al., 2020).

Generating Unique Ideas

This characteristic is raised by FO 1 subjects through the arrangement of answers presented differently from most students in general. Subject FO 1 divides the volume of 216 cm^3 into two equally large parts so that each prism has a volume of 108 cm^3. This unique solution is not only due to wanting to be different, but the subject's ability to maintain the accuracy of calculations. The uniqueness of this idea is supported by the results of interviews which reveal that the two resulting builds will give rise to their own uniqueness if combined. This is in line with the opinion put forward by Torrance (1974) which reveals that originality is interpreted as the ability to produce ideas or ideas that are not common. Balka (1974) added that originality is a rare response that results from a problem. Even though the ideas produced are classified as unique and unusual, students of the Mathematics specialization still show the ability to think logically and systematically, so that the ideas they present remain within the limits of rationality and relevance of the context of the problem.

Ability to Express Ideas

This characteristic is raised by the subject FO 1 through an interpreted form of visualization. Based on the results of interviews conducted with the subject, it was shown that the subject was able to provide a visualization of the unique ideas that were raised. Unfortunately, in the process of working on it the subject does not interpret well. This result is in line with the research of Nugroho et al (2020) who stated that the ability to express creative ideas through visual representation is very helpful in strengthening aspects of students' originality. In addition, a study from Cruz & Breda (2024) confirms that clear expression of ideas, both in the form of images and mathematical symbols, reflects creative mathematical communication skills.

Description of Creative Thinking Characteristics of Science Specialization Students Fluency

In the fluency indicator, there are 6 subjects that show fluency creative thinking skills or students' ability to produce a variety of solutions oriented to 1 concept. Based on the results of the identification that has been carried out, there are 3 general characteristics or characteristics of subjects who have the ability to think creatively fluency.

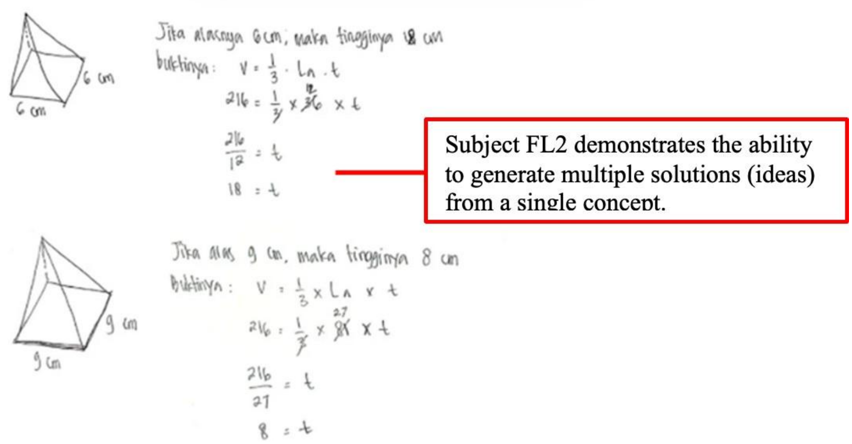

Figure 4. FL 2 Subject Answers

Generate a lot of ideas

Based on the answer of the FL 2 subject when converting the volume of the altar of 216 cm^3 in the form of a block to build another data side space besides the beam and cube, the FL 2 subject was able to present an alternative that was displayed through the variation of the value of the area of the square base. In the process, the subject of FL 2 transformed into 2 different combinations of rectangular filaments to prove that 1 of the same volume could produce different sizes. This is in line with Rahayuningsih et al (2021) research which shows that students with creative thinking skills are able to produce various alternative solutions in open mathematics problems, so that the variety of ideas is an important indicator to measure the level of fluency. This finding is also strengthened by Yayuk et al (2020) who reveals that the fluency of ideas in solving math problems is related to students' ability to think flexibly and systematically.

Have Fluency in Thinking

This ability was demonstrated based on the results of interviews which revealed that FL 2 subjects performed calculations smoothly when applying formulas, despite facing challenges in the multiplication calculation process. The fluency aspect of FL 2 subject also shows that the ideas used by students flow smoothly and vary and are oriented towards 1 concept. FL 2's fluency in thinking is also seen in the speed of determining size combinations and performing calculations. In line with the research of (Kusuma & Retnowati, 2021), students' fluency in thinking in applying formulas is characterized by a smooth, clear, and systematic solution flow that helps accelerate the problem-solving process. This is in line with the findings of Handayani et al (2021) who emphasize that fluent thinking is an important characteristic of creative students who are able to connect concepts smoothly in various situations.

Respond Quickly

Another characteristic that appears in the fluency aspect in science specialization is the ability of the subject to respond to questions quickly. This is shown through the end time, subjects who meet the fluency aspect are completed faster than subjects who meet other aspects. Students who meet these characteristics, have an average of less than 25 minutes of work. This shows that students with fluency skills are considered faster in responding to problems than students with other creative thinking skills. The characteristics of students who are able to respond quickly are in line with the research of Handayani et al (2021) which found that students with fluency skills tend to solve problems faster than students with other creative thinking indicators. In addition, Altintas & Angay (2023) research also revealed that students with quick responses usually have strong logical and systematic skills so that the completion steps are more effective.

Flexibility

In the flexibility indicator, there are 3 subjects that show the ability to think creatively, flexibility, or students' ability to produce a variety of strategies. Based on the results of the identification that has been carried out, there are 2 general characteristics or characteristics of subjects who have the ability to think creatively and flexibility.

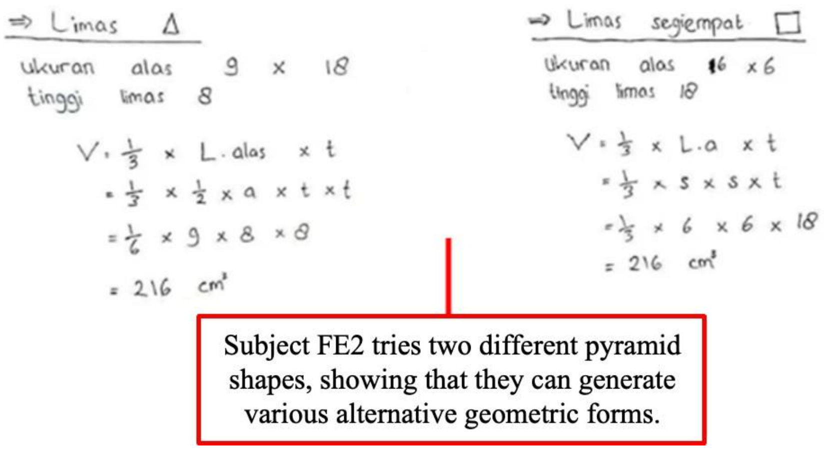

Figure 5. FE 2 Subject Answers

Showing Diversity of Thinking

One of the characteristics that appears in this indicator is the ability of the subject to show the diversity of his thinking. This is shown in the answer of the subject who is able to turn a block-shaped altar into another flat-sided room with different types, namely a triangular pyramid and a quadrangular pyramid. This finding is in line with the research of Rahayuningsih et al (2021) which states that students with the ability to think flexibility can use various strategies in solving problems, resulting in a diversity of perspectives.

Foster (2021) also confirms that diversity of thinking helps students in seeing problems from different perspectives, so they are more open to alternative solutions.

The Ability to Move from One Approach to Another

Subject FE 2 understood that the shapes and formulas used in the two flat-sided space buildings were different. However, both are adjusted in size to produce the same volume. This shows that FE 2 subjects have the ability to explore ideas by moving from one approach to another (geometry to algebraic approaches), so that they are not just oriented towards 1 concept. This is supported by the results of the interviews which reveal that the subjects tried a variety of possible sizes through factors from the initial volume. In line with the research of Rahayuningsih et al (2021), the ability to change strategies is a form of students' cognitive flexibility that allows them to find new solutions through various approaches. In addition, the research of Krulik & Rudnick (1995) revealed that flexibility in thinking is demonstrated through the ability to consider various possibilities and adjust the approach according to the context.

Originality

In the originality indicator, there is only 1 subject that shows the ability to think creatively, originality or the ability of students to create unique ideas. Based on the results of the identification that has been carried out, there are 3 general characteristics or characteristics of subjects who have the ability to think creatively originally.

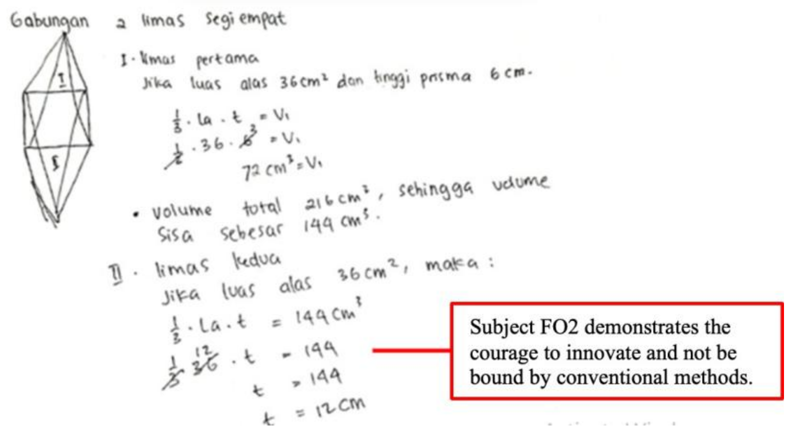

Figure 6. FO 2 Subject Answers

Dare to try out a unique idea

This characteristic is the main characteristic that is needed to bring out the aspect of originality. This is because students' courage to try unique ideas provides opportunities to generate unique ideas. In this case, students have the courage to take risks in finding unique solutions. Foster (2021) also emphasized that students who dare to take intellectual risks are better able to come up with different solutions compared to students who only follow conventional patterns. Algiani et al (2023) added that students' courage in facing challenging problems is a trigger for the emergence of more varied creative ideas.

Generating Unique Ideas

This characteristic is revealed by FO 2 subjects through the arrangement of answers presented that are different from most students in general. In solving problems, FO 2 subjects show thoughts that are not common or rarely used by other students in answering similar questions. Subject FO 2 made a combined 2 rectangular filings with the same base area, but of different heights. This unique solution that comes up is not just a desire to be different, but the subject's ability to maintain the accuracy of calculations. The uniqueness of this idea is supported by the results of interviews which reveal that the subject of FO 2 is trying to find unusual and unique shapes. This finding is in accordance with the opinion of Torrance (1974) who stated that originality is characterized by the ability to generate ideas that rarely appear or are not common in a certain group. Balka (1974) also emphasized that a unique idea is usually a rare response in problem solving.

Ability to Express Ideas

The visualization form interpreted on the subject's answer sheet shows that FO 2 subjects are able to express ideas well. However, in interpreting the form of the viasualization, the subject of FO 2 is still unclear. This is expressed by the subject that the subject feels less skilled in drawing his visualization well. In line with Hsia et al (2021) research, the ability to express creative ideas through visual representation is very helpful in strengthening the originality aspect of students. Fredagsvik (2023) also shows that students who are able to express ideas well have more potential to produce different solutions that remain relevant to the context of the problem.

Description of Creative Thinking Characteristics of Social Studies Specialization Students

Fluency

In the fluency indicator, there are 4 subjects that show fluency creative thinking skills or students' ability to produce a variety of solutions oriented to 1 concept. Based on the results of the identification that has been carried out, there are 3 general characteristics or characteristics of subjects who have the ability to think creatively fluently.

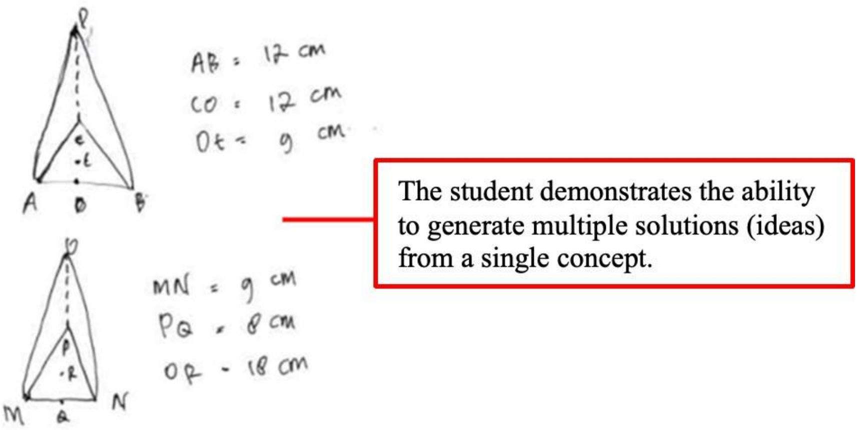

Figure 7. FL 3 Subject Answers

Generate a lot of ideas

This characteristic is demonstrated by the subject of FL 3 when changing the shape of the block to build a flat side space of a triangular pyramid by presenting 2 combinations of sizes. The two alternatives were shown through variations in the size of the triangular base, triangular height, and pyramid height with a volume of 216 cm^3. In the process of determining the size, the subject of FL 3 revealed that the size was obtained through a random number test into the pyramid formula. In line with Handayani et al (2021) research, the ability to generate many ideas is the main characteristic of the fluency indicator which indicates the existence of broad cognitive exploration. Yayuk et al (2020) emphasized that students with high fluency ability can come up with various alternative answers, even though they are oriented towards the same concept.

Have Fluency in Thinking

This characteristic is also shown from the results of the answer of the FL 3 subject when calculating the size of the limas. Students smoothly perform calculations based on different sizes using relevant formulas. The fluency aspect that the FL 3 subject has also shows that the ideas used by students flow smoothly and vary while remaining logical and oriented to 1 concept. Based on the results of the interview, the subjects revealed that they were quite quick in finding alternatives. Research by Shafa et al (2023) added that fluency in thinking accelerates the problem-solving process because students are able to connect information precisely. Wang et al (2024) also found that fluency in thinking greatly affects students' ability to flow ideas quickly when faced with complex problems.

Filtering Logical Ideas

Another characteristic that appears on the fluency indicator is the subject's ability to filter logical ideas. Based on the results of the interview, the subjects considered the logic and proportional size of the answer. The fluency aspect that the FL 3 subject has shows that the ideas used by the students vary while remaining logical and oriented to 1 concept. This can be interpreted that the subject is not only able to explore various ideas, but also able to control the idea to keep it reasonable. In line with Handayani et al (2021) research, the ability to filter logical ideas is an important part of fluency indicators because students need to ensure that their answers are consistent with mathematical logic. Win another research also emphasized that creative students not only produce a lot of ideas, but are also able to filter ideas to keep them relevant and proportional.

Flexibility

In the flexibility indicator, there are 2 subjects that show creative thinking ability, flexibility, or students' ability to produce a variety of strategies. Based on the results of the identification that has been carried out, there are 2 general characteristics or characteristics of subjects who have the ability to think creatively and flexibly.

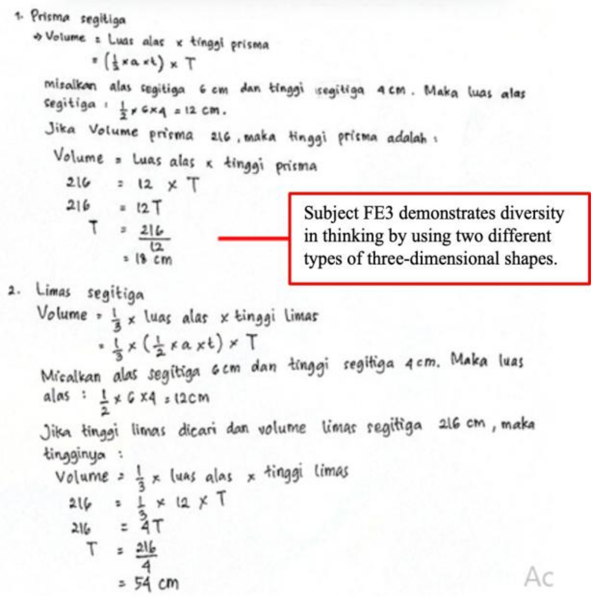

Figure 8. FE 3 Subject Answers

Showing Diversity of Thinking

One of the characteristics that appears in this indicator is the ability of the subject to show the diversity of his thinking. This is shown in the subject's answer that is able to turn a block-shaped altar into another flat-sided space with different types, namely triangular pyramids and triangular prisms. Research by Yayuk et al (2020) found that students with flexibility of thinking are able to use a variety of solution strategies, resulting in a diversity of perspectives. Qorib (2024) also emphasized that diversity of thinking helps students see problems from different perspectives, thus enriching alternative answers.

The Ability to Move from One Approach to Another

Based on the subject's answers, namely two different types of flat-sided space building in the form of a triangular pyramid and building a triangular prism flat-sided space. Subject FE 3 understands that the shapes and formulas used in the two flat-sided space buildings are different. However, both are adjusted in size to produce the same volume. This shows that FE 3 subjects have the ability to explore ideas by moving from one approach to another, so that they are not only oriented to 2 concepts. In line with the research of Idawati et al (2020) the ability to change strategies is proof of students' cognitive flexibility in controlling the thinking process. In addition, Krulik & Rudnick (1995) affirm that flexibility of thinking means considering various possibilities and adapting the approach according to the context.

Originality

In the originality indicator, there is no subject that shows the ability to think creatively, originality or the ability to create their own ideas, unique, and different from other subjects. In general, the subjects in this specialization have not been able to provide a variety of relevant and unique solutions (uncommon forms). So in this indicator, the researcher could not find characteristics or general characteristics of originality of students with a specialization in social studies. Although no social studies subjects displayed an aspect of originality, these findings can still be attributed to previous research. The aspect of originality often does not appear in most students because it takes high courage to display ideas that are different from common habits. The findings of Balka (1974) and (Torrance, 1974) also confirm that originality is a rare response that is difficult to emerge without a strong impulse of creative exploration. Thus, the absence of originality indicators in social studies students is in accordance with previous research which states that aspects of originality tend to be rare and require special stimulus in order to develop.

The findings revealed notable variations in creative thinking characteristics among the three specialization groups: Mathematics, Science, and Social Studies when solving culturally integrated mathematical problems. Mathematics specialization students demonstrated the most comprehensive creative thinking performance, showing fluency, flexibility, and originality. This superior performance can be interpreted through cognitive, motivational, and instructional factors. Cognitively, Mathematics students are trained to engage in abstract reasoning and symbolic manipulation, enabling them to generate diverse ideas and move easily between solution strategies (Nurrahmah et al., 2021). Motivationally, they tend to display higher persistence and curiosity toward challenging problems, which supports their willingness to take intellectual risks an essential aspect of originality. Instructionally, mathematics learning often emphasizes problem-based and inquiry-oriented practices that stimulate creative habits of mind more than other specialization areas.

From an international perspective, these findings align with global frameworks of creative pedagogy such as the OECD Learning Compass 2030, Torrance’s framework, and the 4C Model of Creativity (Dumas & Kaufman, 2024). These frameworks highlight creativity as a multidimensional competency integrating cognitive, social, and emotional domains. Mathematics students’ stronger creative thinking performance may reflect greater opportunities to practice “little-c” creativity everyday creative problem-solving through exposure to nonroutine tasks and abstract reasoning. Research by (Arifin et al., 2021) indicates that engaging students in non-routine mathematical problems fosters creativity aspects such as fluency, flexibility, and originality. Conversely, Science and Social Studies curricula often emphasize factual accuracy and procedural mastery, limiting students’ chances to explore alternative or original ideas.

The integration of cultural contexts also contributed meaningfully to students' creative engagement. Cultural elements helped students link mathematical ideas with familiar real-life situations, consistent with principles of Culturally Responsive Pedagogy (Abdulrahim & Orosco, 2020). However, differences among specializations suggest that Mathematics students were more capable of abstracting cultural representations into mathematical forms, while other groups tended to remain at the surface level of contextual interpretation. This indicates the need for instructional scaffolding to help students from all backgrounds connect cultural understanding with mathematical reasoning.

These results emphasize that creative thinking in mathematics is not merely cognitive but also influenced by motivational and contextual dimensions. Therefore, curriculum and teacher education programs should incorporate culturally responsive and creativity-based instruction across all specialization areas. Teachers must be equipped to design open-ended mathematical tasks, encourage divergent thinking, and integrate local culture into learning. Such practices will strengthen students' creative potential and align classroom learning with international standards of creative pedagogy.

CONCLUSION

This study aimed to analyze the creative thinking characteristics of Grade IX students in solving culturally integrated mathematical problems, viewed from different specialization groups: Mathematics, Science, and Social Studies. The findings showed that Mathematics specialization students demonstrated the highest creative thinking performance, encompassing fluency, flexibility, and originality. Science students also displayed fluency and flexibility, whereas Social Studies students showed these two indicators at lower levels and lacked originality. These differences indicate that students' creative thinking is influenced by cognitive habits, motivational dispositions, and the nature of instructional experiences within each specialization.

Integrating cultural contexts into mathematical problem solving effectively supported students' engagement and meaning-making, although the depth of connection varied among specializations. Mathematics students could translate cultural elements into abstract reasoning, while others tended to remain at a descriptive level. This implies that creativity in mathematics learning is a multidimensional construct that grows through the interplay of cognitive ability, motivation, and culturally responsive pedagogy.

In conclusion, fostering students' creative thinking requires innovative curriculum design and teacher professional development that emphasize open-ended inquiry, problem-based learning, and cultural integration. Such approaches will not only enhance students' creativity across all specializations but also align Indonesian mathematics education with international standards of creative pedagogy.

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