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Unpacking Students' Lack of Flexibility: A Descriptive Analysis of Mathematical Creative Thinking in High School

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Abstrak

Penelitian ini difokuskan untuk menganalisis kemampuan berpikir kreatif matematis siswa SMA dalam menyelesaikan masalah matematika. Metode yang digunakan adalah pendekatan kualitatif deskriptif dengan melibatkan 34 siswa kelas X di salah satu sekolah di Kabupaten Cirebon. Teknik pengumpulan data dilakukan melalui tes, observasi, dan wawancara. Data yang diperoleh dianalisis menggunakan reduksi data, penyajian data, dan penarikan kesimpulan. Temuan penelitian menunjukkan bahwa secara keseluruhan siswa berada pada kategori sedang yang memenuhi indikator kelancaran, orisinalitas, dan elaborasi. Hanya 1 siswa dengan kategori tinggi, 30 siswa kategori sedang, dan 3 siswa kategori rendah. Dominannya kategori sedang disebabkan oleh keterbatasan siswa dalam mengembangkan strategi penyelesaian alternatif. Indikator dengan rata rata tertinggi adalah kelancaran, sedangkan indikator terendah adalah fleksibilitas. Temuan ini menunjukkan bahwa siswa cukup mampu menghasilkan ide, tetapi masih kurang fleksibel dalam menggunakan strategi pemecahan masalah. Sehingga, Kemampuan ini perlu ditingkatkan agar siswa dapat memecahkan masalah dengan berbagai solusi dan memenuhi tuntutan pembelajaran abad ke 21.
***Kata Kunci**: Kreatif; Matematis; Pemecahan Masalah.*

Abstract

This study focused on analyzing the¬ mathematical creative thinking abilities of high school students in solving mathematical problems. The method used was a descriptive qualitative approach involving 34 grade 10 students in one of the schools in Cirebon Regency. Data collection techniques were carried out through tests, observations, and interviews. The data obtained were analyzed using data reduction, data presentation, and drawing conclusions. The research findings showed that overall students were in the medium category that met the indicators of fluency, originality, and elaboration. Only 1 student was in the high category, 30 students were in the medium category, and 3 students were in the low category. The dominance of the medium category was caused by students' limitations in developing alternative solution strategies. The indicator with the highest average was fluency, while the lowest indicator was flexibility. These findings indicate that students are quite capable of generating ideas, but still lack flexibility in using problem solving strategies. Therefore, this ability needs to be improved so that students can solve problems with various solutions and meet the demands of 21st century learning.
Keywords: Creative; Mathematical; Problem Solving.

I. Introduction

In today's era of globalization and technological advancement, 21st century skills are the key for individuals to succeed and contribute to society. Skills needed in the 21st century refer to a set of abilities that enable young individuals to function productively in the knowledge based society, both as professionals and responsible citizens (Lambrechts, 2019). 21st century skills are not only focused on mastering essential knowledge and skills, but also include problem solving, critical, creative, communicative, and collaborative thinking skills (van Laar et al., 2020).

The 4Cs, creativity, critical thinking, communication, and teamwork are essential 21st century skills that show pupils how to cultivate the abilities required for future societal growth (Ye & Xu, 2023). As stated by Zhao et al. (2023), the 4Cs are 21st century competencies that must be used in a variety of contexts. In addition to the job, these 4Cs are crucial for daily living, personal growth, and resolving challenging issues in a world growing more complex by the day. This is consistent with Thornhill Miller et al. (2023), who assert that the 4C abilities are essential for equipping pupils to effectively navigate every obstacle in life's intricate process, hence fostering the development of a strong personality. The skills known as the 4Cs are extremely important in getting students ready to handle fast paced transformations, work in teams, get past tough challenges, and come up with creative answers. Thus, equipping students with 4C skills is crucial to support their success in responding to 21st century demands.

Creative thinking is regarded as a key 21st century skill because it highlights the connection between mathematical concepts and real world situations. Ayyildiz & Yilmaz (2021) stated that in today's world, having the skill to think creatively is incredibly important for navigating life successfully. Ashari et al. (2025) stated that reative thinking is increasingly viewed as an indispensable ability needed to meet the demands of the 21st century, considering that society continues to need innovative solutions to face various unique, complex, and challenging problems. There is a strong relationship between creative thinking ability and creativity (Gunawan et al., 2022). Creativity is a way to gain the ability to think creatively, but the capacity for creative thought is the creativity to be able to achieve unique or unusual ideas or concepts. (Runco & Acar, 2012). Thus, In order to improve the development and discovery of learning concepts in the twenty first century, creative thinking is crucial (Suherman et al., 2021).

The concept of creative thinking in mathematics involves students' skills in formulating unique ideas as part of the problem solving process (Khalid et al., 2020). In line with this, Isyrofinnisak et al. (2020) the capacity to resolve a variety of mathematical issues is the definition of creative thinking in mathematics. In mathematics, creative thinking involves more than just coming up with right answers; it also involves coming up with fresh, original solutions to challenges. It has been demonstrated that pupils' comprehension of mathematical ideas is positively impacted by creative thinking.

(Hadar & Tirosh, 2019). Thus, mathematics instruction should be regarded as a medium for developing students' creative thinking skills (Švecová et al., 2014). Thus, the capacity of pupils to approach mathematical issues in novel ways that go beyond simply comprehending ideas and using formulae is known as mathematical creative thinking.

Rahayuningsih et al. (2021) said creative thinking ability can be measured using indicators of creative thinking ability include fluency , flexibility , originality , elaboration , and novelty (Wahyudi et al., 2020). According to Jebur (2020), fluency, flexibility, and originality are essential components used to assess creative thinking ability. Other researchers also identify indicators of creative thinking ability as flexibility, elaboration, fluency, and originality (Azaryahu et al., 2023; Acar, 2023; Cintamulya et al., 2023; Wan, 2024) ;Kosasih et al., 2024). Fluency represents the capacity to create a multitude of pertinent concepts, expressible through words, phrases, or visuals (Jawad et al., 2021). Flexibility is the skill of conceiving a diverse array of thoughts or notions (Vlasenko et al., 2020; Hariyani et al., 2025). Originality signifies a talent reflecting the quantity of unique answers contrasted with the readily available answers within a specific demographic (Sadak et al., 2022).

Furthermore, the elaboration denotes the aptitude to expand upon ideas and thoroughly explicate the problem addressed, rendering it captivating (Toheri et al., 2020). Novelty is defined as a student's competence in addressing challenges and implementing solutions distinctively from their peers(Wahyudi et al., 2021). Although mathematical creative thinking skills have been formulated through various indicators, in learning practiceIt is commonly observed that students achieving high academic results do not necessarily have good creative thinking skills because they tend to rely on memorizing formulas and routine problem solving procedures without exploring alternative strategies (Arista & Mahmudi, 2020) (Annurwanda & Friantini, 2022). This condition indicates that procedural success does not always reflect students' skills in creatively solving mathematical problems

Mathematical creative thinking skills are considered important, but in reality they are still low and still not meeting expectations (Widiyanto & Yunianta, 2021; Setyaedhi et al., 2025). Furthermore, research by (Sari et al., 2022) the results indicated that students had not yet demonstrated strong creative thinking abilities. Research by Laksono and Effendi (2021) also found that students' capacity for mathematical creative thinking was still classified as low. Students' limited understanding of the questions caused them to respond inconsistently, with some answers given at random and others left unanswered.

Students' low creative thinking skills are evident in their tendency to rely solely on patterns taught by their teachers without seeking alternative strategies (Setyaningsih & Kustiana, 2023). When faced with problems that differ from those exemplified by the teacher, students often experience confusion and are less able to connect previously learned concepts to find new solutions. Meanwhile, solving mathematical problems requires not only procedural skills in applying formulas but also flexibility of thinking, the skill to produce various ideas, and the courage to explore different solution strategies (Joklitschke et al., 2022; Matić & Sliško, 2024).

Several studies have been conducted related to the analysis ofstudents' mathematical creative thin king abilities. However, these studies are still limited to certain materials and certain levels. Research Tamariska et al. (2024) examined Cartesian coordinates in junior high school students. Research Lisnawati & Apriliani (2025) examined Geometry in junior high school students. Research Pratiwi et al. (2022) examined LCM and GCF in elementary school students. These studies have not analyzed students' mathematical creative thinking abilities in the the topic of three variable linear equation systems (SPLTV) at the senior high school level. Therefore, this study provides novelty by analyzing mathematical thinking abilities in the SPLTV material in high school students to fill the limitations of previous research. Thus, the questions in this study are: 1) how can the levels of high school students' mathematical creative thinking ability in solving mathematical problems be identified?; 2) what indicators define each level of mathematical creative thinking ability demonstrated by high school students during problem solving?

II. Method

The type of research used in this study is descriptive qualitative. Qualitative descriptive research is a researchwhose results are described comprehensively based on the research results obtained by researchers (Villamin et al., 2024). This study examined the mathematical creative thinking abilities of high school students and was conducted at a public senior high school in the Cirebon district. The participants consisted of 34 tenth grade (Grade X) students.

This research has been approved by the principal and the confidentiality of students' personal data is guaranteed. This research was validated using technical triangulation analysis consisting of documentation, observation and interviews. Data collection used tests, observations, and interviews. To obtain data on students' mathematical creative thinking abilities, a test was administered, and observational data were collected concurrently during the testing process. To get more detailed information about the motivations behind the students' responses to the questions, interview guidelines were utilized. All students were involved in the initial stages of the creative thinking skills test. In addition, interview subjects were selected using purposive sampling based on test outcomes and students' levels of mathematical creative thinking ability (high, medium, and low), with six students participating in in depth interviews.

The students' mathematical creative thinking ability test contains descriptive questions on the Three Variable Linear Equation System (SPLTV) material, consisting of four questions. The mathematical creative thinking ability test questions have been validated by experts and obtained valid results. The test questions refer to four indicators of mathematical creative thinking ability: flexibility, elaboration, fluency, and originality. Each question represents one indicator. The following test questions are arranged based on the four indicators.

1.	Khumaira bought two pens, a notebook, and a pencil for a total price of Rp12,000. Anisa bought a pen, a notebook, and a pencil for a total price of Rp9,000. and Faiza bought three pens, two notebooks, and a pencil for a total price of Rp19,000. From the statement above, form a substitute variable for the item and its mathematical model. Give at least 2 possible answers!
2.	The price of 2 kg of mango, 2 kg of oranges and 1 kg of grapes is Rp70,000. and the price of 1 kg of mango, 2 kg of oranges, the price of 2 kg of grapes is Rp90,000. If the price of 2 kg of mango, 2 kg of oranges, and 3 kg of grapes is Rp130,000, what is the price of each kg of fruit (mango, orange and grape)? Do it using 2 different ways!
3.	Anwar is 3 years younger than Sinta, and Sinta is 2 years older than Reno. The sum of their ages is 46. Create a question and provide a solution to the question!
4.	For some reason three students Anna, Bob and Chris measured their weight in pairs. Anna and Bob's weight is 226 kg, Bob and Chris 210 kg, and Anna and Chris 200 kg. What is the weight of each student? Answer in detail!

Figure 1. Test Questions.

A data analysis approach that includes data reduction, data presentation, and conclusion drawing was used in this investigation (Miles et al., 2014). Students' creative thinking ability test results were gathered in order to reduce the amount of data. Following the data reduction phase, test results and research subject interviews were used to display the data. Drawing conclusions by summarizing the outcomes of students' mathematical creative thinking skills for each indicator was the last step. This method enables a thorough comprehension of the data and makes it easier to investigate significant insights into the study's conclusions (Halil et al., 2023).

After that, the information gathered from the students' test of mathematical creative thinking skills was analyzed and processed. A score system with a range of 0 to 4 was used to evaluate the students' responses to the creative thinking ability test questions. Each creative thinking ability indicator has different criteria and scores. Guidelines for assessing each indicator of creative thinking ability used are adapted from (Nufus et al., 2024). The results of the student's answer scores are processed by converting them to a scale of 100 using the following formula.

$$Grade = \frac{Student\ Score}{Ideal\ Maximum\ Score} \times 100 \qquad (1)$$

The results are then categorized based on the criteria for the capacity for creative thought. Table 1 classifies the criteria used to evaluate creative thinking skills. Not creative, less creative, moderately creative, creative, and very creative are some of these qualities (Junaedi et al., 2021).

Table 1.
Category of Creative Thinking Skills

Category Determination	Value Criteria	Category
Scores ≥ Mean + SD	Scores ≥ 89	High
Mean − SD ≤ Scores < Mean + SD	60 ≤ Scores < 89	Medium
Scores < Mean – SD	Scores < 60	Low

III. RESULT AND DISCUSSION

In this instance, learning outcomes in the form of test scores are the outcomes of the data analysis from this study. Four creative thinking ability questions about the content of the Three Variable Linear Equation System (SPLTV) served as the research instrument. The overall results of student answers were used as data for analysis, as shown in the Table 2.

Table 2.
The Average Score

Indicators	Item Number	Maximum Score	Average Score
Fluency	1	4	3.56
Flexibility	2	4	2.02
Originality	3	4	2.82
Elaboration	4	4	3.44
Total		16	11.85
Overall Average			2.96

Table 2 presents the students' scores for each mathematical creative thinking item, including the indicators assessed. The results indicate that students demonstrate a moderate level of mathematical creative thinking ability, as reflected by an average score of 2.96, which is close to the maximum possible score of 4. The preceding table makes it clear that the average indication of mathematical creative thinking ability has the lowest average score for flexibility and the highest average score (2.02) for fluency. The overall test results for mathematics creative thinking ability will provide more information as follows in Table 3.

Table 3.
The Overall Results of Mathematical Creative Thinking Skills Tests

Number of Students Obtaining the Score	Item Number			
	1	2	3	4
4	24	2	6	24
3	6	0	25	7
2	3	29	5	0
1	1	3	0	0
0	0	0	2	3

Table 3 shows that the average student is able to analyze and construct an idea, object, or situation in detail. Students successfully answered question number 1, with 24 out of 34 students able to obtain a score of 4 points. This finding indicates that students are capable of solving problems by producing varied and relevant solutions. The results show that 29 students were able to achieve a score of 2 on item 2. This indicates that students were only able to provide one correct answer. Students were also able to answer question number 3, as shown by 25 students able to obtain a score of 3 points. A score of 4 points was also obtained by 24 students on question number 4.

The classification of mathematical creative thinking abilities is based on the following categories.

Table 4.
Categories of Students' Mathematical Creative Thinking Abilitie

No	Category	Student	Percentage
1	High	1	2.94%
2	Medium	30	88.24%
3	Low	3	8.82%
Total		34	100%

Table 4 shows that 2.94% of students fall into the high group of creative mathematical thinking ability, 88.24% of students belong to the medium category, whereas 8.82% are categorized as having low ability, according to Table 4. The majority of students fall within the medium group of creative mathematical thinking ability. According to instructor interviews, one kid falls into the high category since they actively participate in class mathematics instruction. According to their mathematical aptitude, thirty students have a medium capacity for mathematical creativity. Three pupils are not very good in mathematical creativity.

Based on the test results, the fluency indicator showed the highest average score compared to the other indicators. The students' answers are illustrated in the Figure 2.

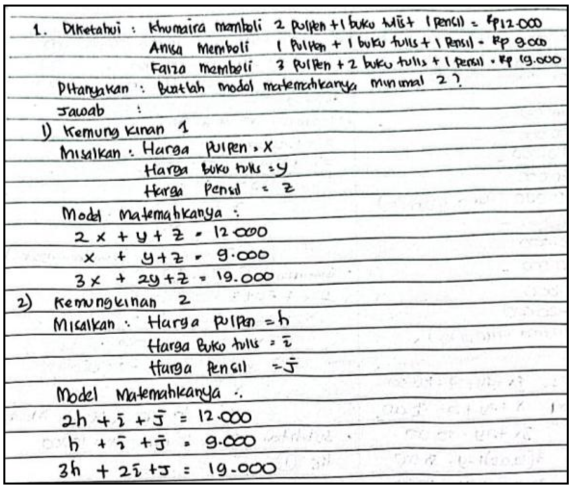

Figure 2. Students' Responses on the Fluency Indicator.

Based on the image above, 75% of students were able to create mathematical models with diverse answers and correct calculation processes. The resulting answers show two diverse solutions, reflecting students' fluency in generating ideas and problem-solving strategies. Interviews with students revealed that they found it easy to create diverse mathematical models using only different variables.

Although the fluency indicator was high, the analysis showed that students' abilities in the flexibility indicator were still low. The results indicate that only 5.9% of students achieved the flexibility indicator. Students classified in the high category were able to apply two different solution methods, while the majority of students (94.1%) failed to meet this indicator. The following section presents the responses of students in the medium category related to the flexibility indicator.

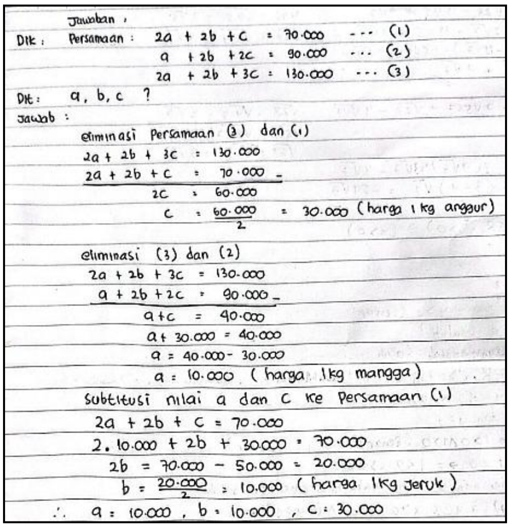

Figure 3. Students' Responses on the Flexibility Indicator.

The Figure 3 indicates that although most students solved the problem correctly using one method, they did not demonstrate the ability to identify alternative solutions. Based on the interview results, the student stated that he understood the instructions for the question that asked for a solution using two different methods. However, on his answer sheet, the student only wrote one method because he felt he only mastered that one solution strategy, while he did not know the other method.

Although he tried to think of alternative solutions, the student was unable to find another method and chose to use the method he was most confident was correct. According to the student, the problem could actually be solved using other methods, but he admitted that he was not used to looking for alternative methods. Students tend to immediately use one method that is considered correct without trying other possible methods. In addition, the fear of getting the answer wrong and the worry of running out of time are the main reasons why students are reluctant to try different solutions.

Furthermore, in the originality indicator, students in the high category were able to formulate questions in their own way based on the problems presented. They were also able to answer with correct calculations and results. This finding indicates that students in the high category possess strong creative thinking abilities and are capable of producing novel and original ideas. An example of a student's response is presented in the Figure 4.

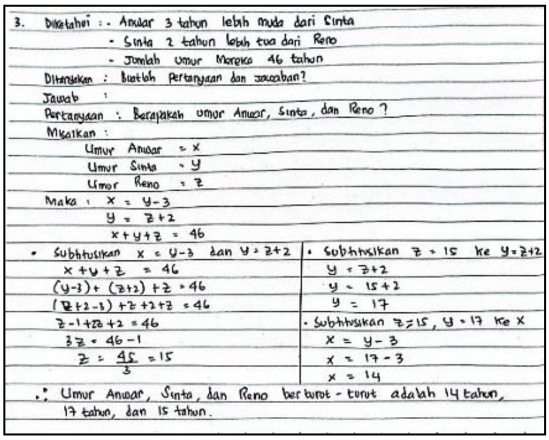

Figure 4. Students' Responses on The Originality Indicator.

Meanwhile, students in the medium category were able to formulate a question based on the problem presented. However, they were not yet able to answer correctly and made calculation errors. Students were less thorough in understanding the information contained in the problem, resulting in errors in their answers. This indicates that students have shown the potential to generate new ideas, despite this, they still need guidance and practice to improve the accuracy of their problem-solving skills. Students in the low category were not yet able to formulate questions based on the problem presented. Students only wrote mathematical models, but they still made mistakes in creating mathematical models of the problem. Based on the interview results, students in the medium category understood the problem in general, but were still unsure about determining the solution steps, resulting in calculation errors. These findings indicate that students in the low category face substantial difficulties in interpreting problem information and transforming it into a mathematical model.

The results of students' answers to the mathematical creative thinking ability test on the elaboration indicator are shown as follows.

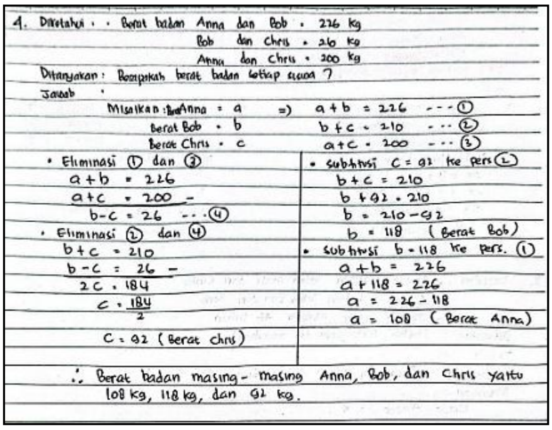

Figure 5. Students' Responses on the Elaboration Indicator.

The figure 5 illustrates that students with high ability were able to fulfill the elaboration indicator by providing detailed and accurate solutions. Students with moderate ability were able to answer in detail, but there were errors in their calculations. Students with low ability to think creatively were not yet able to answer the problems presented. Students faced difficulties in expanding and deepening their ideas, so they did not answer the problems presented. Based on the interview results, students with high ability stated that they were accustomed to

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writing down the solution steps sequentially and re confirming the correctness of each calculation.

Meanwhile, students with moderate ability stated that they were still not careful in carrying out calculations even though they understood the solution steps. Meanwhile, students with low ability stated that they had difficulty answering and explaining the solution steps in detail because they did not yet understand the concepts used.

According to previous studies, high creative thinking ability in students is characterized by four key indicators: fluency, flexibility, originality, and elaboration. These four indicators are interrelated and serve as markers of strong creative thinking skills. In the fluency indicator, students are able to write down known information, questions, and provide examples of the problems presented. This indicates that students can answer questions fluently (Yayuk et al., 2020). The capacity to come up with as many ideas as possible in a brief amount of time is referred to as fluency. Students who meet the flexibility indicator demonstrate the capacity to approach problems from various perspectives and apply different solution methods.

Students who meet the originality indicator show the ability to generate original ideas by formulating problems and solutions using unconventional approaches. According to Thomas (2015), the sudden emergence of new ideas is always based on existing things. With respect to the elaboration indicator, students are able to present detailed and well developed solutions. This indicator reflects the ability to expand initial ideas into more complete and structured forms. These findings are supported by Syawaludin et al. (2024), who reported that fluency, flexibility, originality, and elaboration characterize high levels of creative thinking ability.

The indications of fluency, originality, and elaboration are met by students with medium creative thinking abilities. Pupils that exhibit creative thinking abilities with signs of originality, fluency, and elaboration have a remarkable capacity to produce fresh, original ideas. In contrast, students in the low category fail to meet all four indicators of mathematical creative thinking ability. This is consistent with the findings of a study conducted by Yaniawati et al. (2020), which discovered that when it comes to solving mathematical problems, children with low creative thinking skills lack elaboration, fluency, flexibility, and originality. This causes students to be unable to provide solutions to the problems given (Wahyudi et al., 2020). Students forget or even do not know the basic concepts that have been learned previously. Students feel afraid when learning mathematics, so the material presented is not stored in their memory.

In the fluency indicator, most students were able to answer questions with multiple ideas and were able to answer fluently and accurately. The flexibility indicator reflects students' ability to employ different solution strategies by viewing problems from multiple perspectives (Hidajat, 2022). These findings suggest that the emergence of original ideas is evidence of both a clear understanding of the problem and the ability to generate appropriate and creative solutions. This is in line with Ibrahim and Widodo (2020), who stated that students who have the ability to communicate various ideas, solutions, and problem solving are known as students who have fluent thinking skills. The highest indicator attained by students was fluency, in line with previous studies by Pratama et al. (2023) and Sari et al. (2022).

However, the achievement of the flexibility indicator is very low. The findings indicate that the majority of students relied on only one method to solve the problems, yielding correct calculations and answers. This is because students are not accustomed to finding different methods, feel less confident, and are worried about getting the answer wrong or running out of time. This indicates a flexibility gap, namely the difference between students' ability to produce answers fluently and their ability to find answers using other different methods. (Leikin & Elgrably, 2020) suggest that fluency of thinking is not always followed by flexibility, especially when students are accustomed to solving problems using only one method. The fluency indicator reflects the speed and volume of idea generation, while flexibility indicates a student’s capacity to approach problems through multiple methods or perspectives (López Martínez et al., 2024) (Pehlivan & Coşkun, 2025).

Low student flexibility can be caused by various factors, one of which is teacher centered learning. This learning pattern tends to make students focus on examples given by the teacher without trying other ways to solve problems. This results in students being less trained in finding various alternative solutions (Vale & Barbosa, 2024) (Lucas, 2025). Students' fear of making mistakes in solving problems and limited time also further strengthens students' tendency to solve problems using only one method they are most familiar with. This shows that flexibility is not only about cognitive abilities, but also closely related to the environment and learning experiences experienced by students (Wang & Jou, 2023).

The findings suggest that a learning environment that is both productive and open can effectively support the growth of students’ flexibility in problem solvingAn environment that fosters investigation, discussion, and exploration helps students try various methods to solve problems (Ndiung et al., 2021). This aligns with Niu et al. (2022), who reported that most studies indicate a creative learning environment positively influences students’ creative thinking skills. Therefore, teachers need to design challenging yet psychologically safe classroom activities and interactions so that students are encouraged to express original ideas, try various problem-solving strategies, and reflect on their thinking processes without fear of making mistakes (Hsia et al., 2021; Charteris et al., 2024).

IV. Conclusion

This study concluded that secondary school students' creative mathematical thinking skills were generally at a moderate level, with fluency as the highest indicator and flexibility as the lowest. Although students were able to generate ideas

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fluently and produce correct solutions, most relied on a single, familiar method and demonstrated limited ability to explore alternative strategies, indicating a clear flexibility gap. This gap is influenced not only by students' thinking skills but also by learning experiences that emphasize one correct procedure, a fear of making mistakes, time constraints, and teacher centered learning. Therefore, mathematics teachers are encouraged to implement open ended tasks, facilitate discussions about various solution strategies, and create a psychologically safe learning environment that supports exploration.

This study contributes to mathematics education by highlighting flexibility as a crucial component of students' creative mathematical thinking. However, the findings are limited by the small sample size, focus on a single school, and restriction to a single mathematics topic. Future research is recommended to explore teaching interventions that specifically promote flexibility across various mathematics domains, educational levels, and learning contexts.

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