

How Cognitive Styles Shape Creative Mathematical Thinking

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Abstract:

Creative thinking is widely recognized as a core component of higher-order thinking in mathematics education; however, its development among Indonesian students remains a persistent challenge, as reflected in large-scale international assessments such as PISA 2018. Differences in students' cognitive styles particularly reflective, impulsive, and slow-inaccurate styles are assumed to shape cognitive processing and mathematical problem-solving performance, yet empirical evidence remains limited. This study aims to examine students' creative thinking ability in mathematical problem solving from the perspective of these cognitive styles. Employing a qualitative descriptive approach, the participants were eighth-grade students from SMP Negeri 2 Sumbergempol Tulungagung, classified using the Matching Familiar Figure Test (MFFT). Data were obtained through problem-solving tests and semi-structured interviews and analyzed through methodological triangulation. The findings indicate that students with reflective cognitive styles exhibit a high level of creative thinking, characterized by fluency, flexibility, and originality. In contrast, students with impulsive and slow-inaccurate cognitive styles demonstrate moderate creative performance, predominantly reflected in elaborative responses. These results highlight the need for differentiated instructional strategies that align with students' cognitive characteristics. The study contributes to the growing body of literature on cognitive style-based instruction and offers pedagogical insights for fostering creative thinking in mathematics classrooms.

Keywords: : Creative thinking; Cognitive style; Mathematics education

Introduction

Creative thinking is an essential ability in mathematics learning, particularly in solving non-routine and complex problems. This ability allows students to generate diverse ideas, apply flexible strategies, and produce original solutions. In mathematics education, creative thinking has been recognized as a key competence that supports meaningful learning and problem solving. Suherman and Vidákovich (2022) emphasized that creative thinking plays a crucial role in mathematics learning, especially in problem-solving activities that require students to explore various



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solution strategies. Despite its importance, students' creative thinking ability in mathematics remains low, both internationally and nationally. Several studies have reported that many students experience difficulties in developing creative ideas when solving mathematical problems (Titikusumawati et al., 2019; Tan et al., 2020). This condition is also reflected in the Programme for International Student Assessment (PISA) 2018 results, where Indonesian students ranked 72nd out of 78 participating countries, indicating limited performance in higher-order and creative mathematical thinking (Hadayana et al., 2023). These findings suggest that low creative thinking ability is a persistent issue that requires serious attention in mathematics education.

One factor that may influence students' creative thinking in mathematics is cognitive style. Cognitive style refers to an individual's consistent way of processing and responding to information. Differences in students' mathematical abilities are often related to how they process information cognitively (Mubarok & Kurniasari, 2019). According to Maiti and Pardi (2023), cognitive style plays an important role in students' understanding of mathematical concepts and in determining how they approach problem solving. Therefore, examining cognitive style provides a theoretical basis for understanding variations in students' creative thinking performance. Conceptual tempo is one classification of cognitive style that includes reflective, impulsive, fast-accurate, and slow-inaccurate types (Simamora & Akhiruddin, 2022). Reflective students tend to respond slowly but accurately, impulsive students respond quickly but are more prone to errors, while slow-inaccurate students respond slowly with lower accuracy. These differences indicate that students may demonstrate creative thinking in different ways depending on their cognitive style. Teachers, therefore, need to understand these characteristics to support students effectively, as learners within the same classroom may process and analyze information differently (Rismen et al., 2020).

To operationalize the classification of conceptual tempo within cognitive style, this study employs the Matching Familiar Figure Test (MFFT), a well-established instrument developed by Jerome Kagan and colleagues to distinguish between reflective and impulsive learners. The MFFT requires students to select a figure identical to a given standard image from several similar options, while both response time and accuracy are recorded. Through this mechanism, students who respond slowly with high accuracy are identified as reflective, whereas those who respond quickly with more errors are categorized as impulsive. This instrument has been widely used in educational research to examine how individuals regulate cognitive

processes and decision-making strategies when solving problems. Moreover, the MFFT provides an empirical basis for linking cognitive style to learning performance, particularly in mathematics, where accuracy and strategic thinking are crucial. By using the MFFT, this study is able to systematically classify students' cognitive styles and further analyze how these differences contribute to variations in creative thinking (Kagan et al., 1964; Messer, 1976; Cairns & Cammock, 1978).

Previous studies have examined students' creative thinking ability in mathematics based on cognitive style. Febrianingsih (2022) explored students' creative thinking in mathematical problem solving, while Sa'adah et al. (2019) focused on reflective cognitive style in mathematics learning. Herianto and Hamid (2020) analyzed creative thinking processes in geometry problem solving based on reflective and impulsive cognitive styles. However, these studies mainly emphasized reflective and impulsive students, with limited attention given to slow-inaccurate cognitive style. As a result, there is still a lack of understanding of how students with slow-inaccurate cognitive style demonstrate creative thinking in mathematics.

Based on cognitive style theory and creative thinking frameworks, this study addresses the existing research gap by including reflective, impulsive, and slow-inaccurate cognitive styles. The inclusion of the slow-inaccurate group represents the novelty of this study and provides a more comprehensive view of students' creative thinking in mathematics. Therefore, this study aims to describe students' creative thinking abilities in solving mathematical problems based on reflective, impulsive, and slow-inaccurate cognitive styles, with the expectation that the findings can inform more adaptive and inclusive mathematics instruction.

Research Methods

This study adopted a descriptive qualitative research design to systematically examine students' creative thinking abilities in mathematical problem solving. A qualitative approach was deemed appropriate because it enabled an in-depth exploration of students' cognitive processes and allowed for a comprehensive description of variations in creative thinking across different cognitive styles. The participants of this study were X eighth-grade students from a public junior high school in Indonesia. The selection of participants was conducted using purposive sampling to ensure representation of different cognitive styles. Initially, all students

were administered the MFFT to classify their cognitive styles. Based on the results, X students representing reflective, impulsive, and slow-inaccurate categories were selected as research subjects. The selection criteria included students' willingness to participate, completeness of test responses, and clear representation of each cognitive style category.

The creative thinking test consisted of X open-ended mathematical problems designed to measure students' abilities across four indicators: fluency, flexibility, originality, and elaboration. Each item required students to provide multiple solution strategies and justify their reasoning. The instrument was validated by experts in mathematics education to ensure content validity. Furthermore, a pilot test was conducted to examine the reliability of the instrument, which was calculated using [Cronbach's Alpha/inter-rater reliability], yielding a coefficient of [e.g., $\alpha = 0.82$], indicating high reliability. In addition, the Matching Familiar Figure Test (MFFT), originally developed by Jerome Kagan, was used to classify students' cognitive styles based on response time and accuracy. The MFFT has been widely recognized as a reliable instrument for distinguishing reflective and impulsive cognitive styles.

Data analysis was conducted using an interactive model consisting of data reduction, data display, and conclusion drawing. In the data reduction stage, students' written responses and interview transcripts were systematically coded based on the indicators of creative thinking. The assessment of creative thinking was guided by indicators adapted from Munandar as cited in Suharsono et al. (2021) and Silver as cited in Cintia et al. (2018), which include fluency, flexibility, originality, and elaboration. These indicators served as the analytical framework for categorizing and interpreting students' responses. Furthermore, students' answers in the creative thinking test were scored using a predetermined rubric aligned with these indicators. The obtained scores were then converted into percentages and classified into levels of creative thinking ability based on established criteria. Meanwhile, qualitative data from semi-structured interviews were analyzed using thematic analysis to explore students' reasoning processes, solution strategies, and cognitive characteristics in greater depth.

To ensure the credibility of the findings, technique triangulation was employed by comparing data obtained from the written test results and interview transcripts. The consistency between these data sources was used to validate the interpretation of students' creative thinking abilities across different cognitive styles. Conclusions were drawn based on the integration of quantitative scoring results and qualitative insights to comprehensively address the research objectives.

Table 1. Indicators of Creative Thinking Ability

Indicator	Sub Indikator
Fluency	Able to fluently generate several relevant ideas
Flexibility	Able to produce a variety of solutions in solving a problem.
Originality	Able to find solutions to problems using new or original ideas and to express personal opinions in response to given situations.
<i>Elaboration</i>	Able to systematically elaborate the given information in a sequential manner to facilitate more detailed problem solving.

The researchers collected students' responses and assigned scores based on a predetermined scoring rubric. The scores were then converted into percentages using the following formula:

$$\text{Score} = \frac{\text{Obtained Score}}{\text{Maximum Score}} \times 100$$

The scores were converted into percentages using a standard formula to facilitate interpretation and comparison across students (Arikunto, 2013). Subsequently, the percentage scores were transformed into categorical values to determine the level of students' creative thinking ability. The categorization criteria were adapted from the framework proposed by Siswono, as cited in Muslimah and Listiyani (2022), as presented below.

Table 2. Levels of Students' Creative Thinking Ability

Score (%)	Level
$86 \leq N \leq 100$	Level 4 (Very Creative)
$70 \leq N \leq 85$	Level 3 (Creative)
$55 \leq N \leq 69$	Level 2 (Moderately Creative)
$45 \leq N \leq 54$	Level 1 (Less Creative)
$0 \leq N \leq 44$	Level 0 (Not Creative)

(Muslimah & Listiyani, 2022)

Results and Discussions

The research subjects were selected based on the results of the Matching Familiar Figure Test (MFFT). The MFFT results for Class VIII-A at SMP Negeri 2 Sumbergempol

indicated that, out of 34 students, 8 students (23%) exhibited a reflective cognitive style, 5 students (15%) demonstrated an impulsive cognitive style, and 21 students (62%) were categorized as having a slow-inaccurate cognitive style. This distribution shows a clear predominance of the slow-inaccurate cognitive style within the class, suggesting that a substantial proportion of students required longer response times while still experiencing difficulties in achieving accuracy. In addition to the commonly identified reflective and impulsive cognitive styles, this study identified the presence of a slow-inaccurate cognitive style among the students, which has received relatively limited attention in previous mathematics education research. This finding adds complexity to the understanding of how students process information during mathematical problem solving, as response time and accuracy do not always develop proportionally. Furthermore, the dominance of the slow-inaccurate cognitive style highlights the importance of adopting more individualized and adaptive instructional approaches that consider students' cognitive characteristics, particularly in supporting the development of higher-order and creative thinking skills in mathematics classrooms.

To ensure that the selected research subjects accurately represented the defining characteristics of each cognitive style identified through the Matching Familiar Figure Test (MFFT), a secondary and more refined selection procedure was implemented. This procedure emphasized two critical dimensions of conceptual tempo, namely response time and response accuracy, which are fundamental indicators for distinguishing reflective, impulsive, and slow-inaccurate cognitive styles. By applying these criteria, the selection process aimed to capture not only categorical differences in cognitive style but also meaningful variations in students' information-processing patterns during mathematical problem solving. From the data obtained from Class VIII-A, the research subjects were further selected based on response time and response accuracy, as presented in Table 3.

Table 3. Selected Study Participants

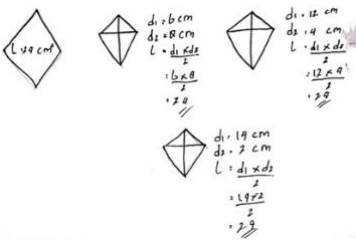
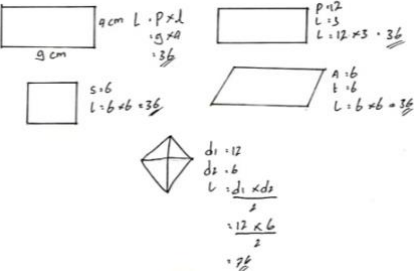
Cognitive Style	Selected Subject	Time	Frequenc y	Code
Reflektif	SAP	13.51	7	AB
Impulsif	RASW	3.35	1	AC
<i>Slow-inaccurate</i>	SA	13.40	6	AD

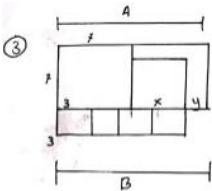
Students' Creative Thinking Ability with a Reflective Cognitive Style

Based on the results of the creative thinking ability test, AB exhibited characteristics that were consistent with the indicators of creative thinking ability listed in Table 4, as follows:

Based on the results of the creative thinking ability test, AB demonstrated characteristics that aligned with the indicators of creative thinking ability listed in Table 4, as follows:

Table 4. Results of AB Student Data Analysis

Indicator	Analysis Results	Score
Fluency	<p>Demonstrated the ability to generate more than one relevant idea and to produce clear and appropriate solutions, such as decomposing and determining the diagonal lengths of several kite-shaped plane figures whose areas were identical to that of a predetermined rhombus.</p> 	4
Flexibility	<p>Demonstrated the ability to provide solutions using multiple methods and different calculation procedures to achieve correct results. illustrated and identified four other square geometric figures that had the same area as the specified paper size.</p> 	4
Originality	<p>Independently provided solutions, performed accurate calculations, and obtained correct results, specifically in determining the side length and perimeter of the shaded square in the given problem.</p>	4

Indicator	Analysis Results	Score
	<p>b. Panjang A = $7 + 7 = 14$ Panjang $y = A - B = 14 - 12 = 2$ Panjang B = $3 + 3 + 3 + 3 = 12$ Panjang $x = 7 - y = 5$ Keliling yg di arsir = $4 \times 5 = 20$</p> <p>c. Beri nama seperti gambar, lalu hitung A, B, y dan x sehingga di ketahui panjang sisi Persegi yang diarsir</p>	
Elaboration	<p>Student was able to systematically elaborate the given information in a sequential manner, thereby facilitating a more detailed problem-solving process; however, was not yet able to clearly identify what was being asked in the problem, particularly in specifying the details to be understood and determined in the applied task.</p>  <p>a. terdapat 6 persegi, 2 persegi identik dengan panjang sisi 7 satuan 4 persegi identik dengan panjang 3 satuan</p>	3
Total Score		15
Score (%)		93,75%

Student AB demonstrated a very high level of creative thinking ability, characterized by fluency in generating multiple relevant ideas and producing appropriate solutions. Flexibility was also evident through the ability to illustrate and determine several plane figures using different approaches, while originality was reflected in the unique solutions produced during the problem-solving process. However, AB showed limitations in elaboration; although the given information was described in greater detail, the student did not clearly specify what was being asked in the problem. This pattern suggests that a reflective cognitive style does not uniformly guarantee the fulfillment of all creative thinking indicators, particularly elaboration, as often assumed in the literature. This finding is not fully aligned with the perspective of Maryanto and Siswanto (2021), who reported that, in terms of creative thinking indicators, only flexibility was achieved, and it also contrasts with Miatun and Nurafni (2019), who suggested that reflective students tend to perform well in both fluency and elaboration.

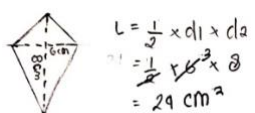
Overall, AB achieved Level 4 (very creative) in creative thinking ability, with a score of 93.75%. This result supports the categorization proposed by Maiti and Pardi

(2023), who identified “very creative” as a characteristic level of reflective students. In line with Sa’adah et al. (2019), reflective students in mathematics learning are generally able to meet the indicators of fluency, flexibility, and originality. Nevertheless, the present findings extend this theoretical understanding by indicating that elaboration may function as a more sensitive and context-dependent indicator, even among students with a reflective cognitive style. This result differs from Tuowa (2019), who reported that reflective students were able to clearly explain both what was known and what was being asked. Thus, the findings contribute to a more nuanced theoretical view that reflective cognitive style supports creative thinking primarily through idea generation and solution diversity, while elaboration may require additional cognitive or contextual support.

Students’ Creative Thinking Ability with an Impulsive Cognitive Style

Based on the results of the creative thinking ability test, AC exhibited characteristics that were consistent with the indicators of creative thinking ability listed in Table 5, as follows:

Table 5. Results of Data Analysis for Student AC

Indicator	Analysis Results	Score
Fluency	<p>Students demonstrated limitations in generating more than one relevant idea and in producing accurate and well-detailed solutions. They were only able to identify and determine the area of a single kite-shaped plane figure equivalent to the area of a predetermined rhombus.</p>  <p>The diagram shows a kite-shaped plane figure with diagonals. The calculation next to it is: $L = \frac{1}{2} \times d_1 \times d_2$, $= \frac{1}{2} \times 6 \times 8$, $= 24 \text{ cm}^2$.</p>	2
Flexibility	<p>Students showed the ability to produce varied answers and calculation processes that led to correct results, such as drawing and identifying four alternative square figures with areas equivalent to the specified paper size. However, inaccuracies were found in the use of mathematical notation, where the concept of “area” was incorrectly denoted by a symbol representing “perimeter.”</p>	3

Indicator	Analysis Results	Score
Originality	<p>Students were able to generate unique solution approaches and perform calculations accurately, particularly in determining the side length and perimeter of the shaded square. Nevertheless, inconsistencies were observed in selecting the appropriate side length for the calculations.</p> <p>b. Panjang sisi persegi yg di arat lebih dari 2 kurang dari 6 Jika sisi aratiran = 6. Maka panjang sisi 3 & 2 Jika sisi mengurakan bilangan bulat kemungkinan: * Panjang sisi 4 cm maka keliling = 4 x 4 = 16 cm * Panjang sisi 5 cm maka keliling = 4 x 5 = 20 cm o. Ukuran tersebut dapat dilihat dari gambar di mana panjang sisi aratiran lebih dari 1 persegi kecil yang panjangnya 3 cm, tapi kurang dari 2 persegi kecil</p>	3
Elaboration	<p>Students were capable of elaborating the given information in a systematic and sequential manner, which supported a more detailed problem-solving process, including clearly identifying the known information and the questions posed in the problem.</p> <p>a. Diketahui: 2 persegi besar memiliki sisi 7 satuan * 4 persegi kecil memiliki sisi 3 satuan. Ditanya: Ukuran persegi yang di aratiran?</p>	4
Total Score		12
Score (%)		75,00%

Student AC exhibited limited fluency in determining the diagonal lengths of multiple plane figures and demonstrated insufficient flexibility in constructing and identifying alternative quadrilateral configurations. The originality indicator was not fully achieved, as the student failed to explicitly justify or finalize a solution strategy. In contrast, student AC showed strong elaboration skills by systematically organizing the given information, clearly identifying known quantities, and explicitly stating the problem requirements. This pattern partially diverges from the findings of Maryanto and Siswanto (2021), who suggested that students with an impulsive cognitive style typically fulfill both flexibility and elaboration indicators.

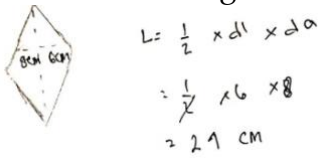
Overall, student AC attained Level 3 (creative) in creative thinking ability, with a score of 75.00%, predominantly supported by performance in the elaboration indicator, while fluency, flexibility, and originality remained underdeveloped. This

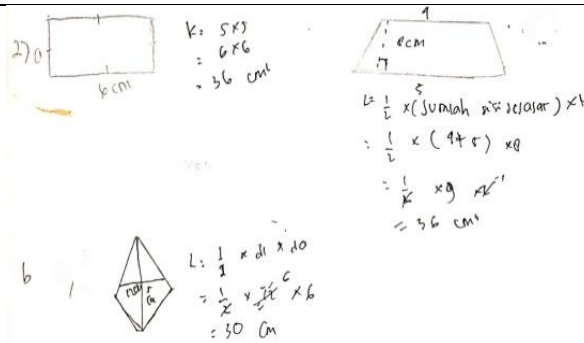
result is consistent with Maiti and Pardi (2023), who classified impulsive students' creative thinking ability at the *creative* level. However, it contrasts with Miatusun and Nurafni (2019), who reported that impulsive students tend to inadequately meet all creative thinking indicators and are therefore categorized as *not creative*. Theoretically, these findings suggest that impulsive cognitive style does not uniformly hinder creative thinking but may selectively support specific components, particularly elaboration. This indicates that creative thinking should be conceptualized as a multidimensional construct in which different cognitive styles activate distinct indicators rather than uniformly influencing overall performance. Consequently, instructional and assessment frameworks grounded in creative thinking theory should account for the uneven manifestation of creativity indicators across cognitive styles, rather than relying on a single aggregated classification.

Students' Creative Thinking Ability with a Slow-Inaccurate Cognitive Style

Based on the results of the creative thinking ability test, SGKS demonstrated characteristics that were consistent with the indicators of creative thinking ability presented in Table 6, as follows:

Table 6. Results of the Data Analysis for Students with a Slow-Inaccurate Cognitive Style

Indicator	Analysis Results	Score
Fluency	<p>The student demonstrated limited fluency in generating multiple relevant ideas and accurate, well-articulated solutions. The response was confined to drawing and determining the diagonal lengths of a single kite-shaped figure whose area was equivalent to that of the given rhombus.</p>  <p>The diagram shows a rhombus with diagonals labeled 'd1' and 'd2'. Below it, the following calculations are written:</p> $L = \frac{1}{2} \times d1 \times d2$ $= \frac{1}{2} \times 6 \times 8$ $= 24 \text{ cm}$	2
Flexibility	<p>The student was unable to employ multiple solution strategies or calculation procedures to obtain correct results. Only two quadrilateral figures of different sizes were identified.</p>	3



Fluency	No response was provided for this indicator.	0
Flexibility	The student was able to systematically organize the given information by clearly identifying the known elements and the questions posed, thereby facilitating a more detailed problem-solving process.	4
<p>A Diketahui : 2 persegi besar memiliki sisi 7 satuan ~ 1 persegi kecil memiliki sisi 3 satuan hitung = ukuran persegi yg terbesar</p>		
Total Skor		9
Nilai		56,25%

The student coded as AC demonstrated notable limitations in creative thinking fluency, as evidenced by the ability to draw and determine diagonal lengths for only a single kite-shaped figure. Flexibility was also weak, as the student identified merely two quadrilateral figures of different sizes and failed to explore alternative solution strategies. No response was provided for the originality indicator, indicating an absence of novel or self-generated ideas. In contrast, the student showed relatively strong performance in elaboration, systematically organizing the given information in a sequential manner that supported a more detailed problem-solving process. Overall, the student with a slow-inaccurate cognitive style achieved Level 2 (moderately creative) with a score of 56.25%, meeting only the elaboration indicator.

These findings are consistent with Padian et al. (2023), who reported that students with a slow-inaccurate cognitive style tend to experience difficulties in interpreting problems, transforming problem representations, demonstrating procedural skills, and articulating final answers. However, a partial divergence is observed in procedural aspects, as the student in this study was able to elaborate the given information despite limitations in other indicators. This result is supported by Alfiana (2022), who noted that slow-inaccurate students are generally capable of identifying known information within a problem. Nevertheless, the findings contradict Ismiyati (2023), who argued that students with a slow-inaccurate cognitive style are unable to provide coherent explanations. Furthermore, the absence of fluency in this study indicates that the student was unable to effectively transform the problem

into multiple meaningful representations, reinforcing the theoretical view that slow-inaccurate cognitive processing constrains creative mathematical thinking.

Discussion

The findings of this study demonstrate that students' creative thinking ability in mathematics varies systematically across reflective, impulsive, and slow-inaccurate cognitive styles. Students with a reflective cognitive style exhibited the highest level of creative thinking by fulfilling the indicators of fluency, flexibility, and originality. This pattern indicates that reflective learners are more capable of generating multiple relevant ideas, exploring alternative strategies, and producing original solutions. These results align with prior studies suggesting that reflective students tend to process information carefully and accurately, allowing them to engage in deeper cognitive exploration during mathematical problem solving (Sa'adah et al., 2019; Maiti & Pardi, 2023). However, the partial limitation observed in elaboration suggests that even highly creative students may struggle to explicitly articulate problem demands, supporting the notion that creative thinking indicators do not always develop uniformly (Maryanto & Siswanto, 2021).

In contrast, students with an impulsive cognitive style demonstrated a moderate level of creative thinking, primarily characterized by their ability to elaborate problem information. While these students were able to describe known information and identify what was being asked, they showed limitations in fluency, flexibility, and originality. This finding supports previous research indicating that impulsive learners often prioritize speed over accuracy, which restricts their capacity to generate and refine diverse solution strategies (Miatun & Nurafni, 2019; Maiti & Pardi, 2023). The dominance of elaboration among impulsive students suggests that structured reasoning can occur even when idea generation is limited. Nevertheless, the inconsistency between this study and prior findings particularly regarding flexibility highlights the contextual nature of creative thinking development and underscores the influence of task characteristics and instructional experiences (Maryanto & Siswanto, 2021).

Students with a slow-inaccurate cognitive style exhibited the lowest level of creative thinking, fulfilling only the elaboration indicator. Although these students were able to identify and organize given information, they experienced significant

difficulty in generating multiple ideas, varying strategies, and producing original solutions. This finding is consistent with studies reporting that slow-inaccurate learners struggle with problem transformation and solution execution despite being able to recognize known information (Alfiana, 2022; Padian et al., 2023). The absence of fluency and originality among these students suggests that careful but inaccurate processing limits the activation of higher-order creative indicators. These results further emphasize that elaboration alone does not signify advanced creative thinking and that effective mathematical creativity requires the integration of multiple indicators, which is strongly mediated by cognitive style (Ismiyati, 2023).

Conclusions and Suggestions

This study confirms that students' creative thinking ability in mathematics is closely associated with cognitive style, with reflective students demonstrating the most integrated creative profiles, impulsive students showing moderate creativity dominated by elaboration, and slow-inaccurate students exhibiting constrained creative performance. These findings highlight that creative thinking is a multidimensional construct whose indicators emerge differently according to cognitive processing characteristics, particularly cognitive tempo and accuracy. The identification of the slow-inaccurate cognitive style further extends existing perspectives on mathematical creativity by revealing a distinct pattern of detailed yet limited problem transformation. Consequently, this study underscores the importance of differentiated instructional approaches that accommodate cognitive diversity to more effectively foster students' creative thinking in mathematics.

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