Profile of Creative Thinking of Students with Mathematical Logical Intelligence in Solving Function Composition

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Abstract
Creative thinking in students is essential in the learning process**.** It can help students discover new ways to understand and solve problems. Through creative thinking, students do not merely focus on finding the correct answer but also learn to explore various possibilities and ideas. This study aims to obtain a description of students' creative thinking profiles with logical-mathematical intelligence in solving mathematical problems, viewed from their learning styles. The focus is on how students with logical-mathematical intelligence utilize creative thinking in accordance with their individual learning styles. This research employs a qualitative approach. The research subjects are three 10th-grade high school students, each representing a combination of logical-mathematical intelligence with a different learning style: visual, auditory, and kinesthetic. Data were collected through students' written responses and interviews. The results of the study show that at the stage of understanding the problem, subjects with logical-mathematical intelligence across all three learning styles demonstrated aspects of fluency and flexibility. At the planning stage, the visual and kinesthetic learners met all aspects of creative thinking, including fluency, flexibility, and novelty. In contrast, the auditory learner demonstrated only fluency and flexibility. At the stage of carrying out the plan, visual and kinesthetic learners again showed all aspects of creative thinking more completely than the auditory learner, who only demonstrated fluency and flexibility. However, in the reviewing stage, all subjects showed only fluency and flexibility, without the presence of novelty. These findings highlight the importance of considering students' learning styles in developing creative thinking skills, particularly for those with logical-mathematical intelligence. An effective learning process must be designed with differentiation, taking into account students' learning styles. With appropriate strategies, students can not only understand the material well but also fully develop their creative thinking potential at each stage of problem-solving.
Keywords: Creative Thinking, Logical-Mathematical Intelligence, Learning Style, Function Composition

Introduction

The term *creativity* is closely related to *creative thinking* (Siswono, 2018). This is evident from the views of several experts who consider creative thinking to be synonymous with creativity itself. Creative thinking is a component of *divergent thinking*. It is a mental process that involves the ability to generate new and innovative ideas in problem-solving (Guilford, 1950; Siswono, 2018). With the advancement of 21st-century learning, the ability to think creatively has become increasingly important. Creative thinking is one of the essential skills that students must possess and develop in mathematics learning as an effort to meet the challenges of the 21st century (Mashitoh et al., 2019). Furthermore, according to Perdana and Sugara (2020), creative thinking is a life skill that needs to be developed to navigate the information age and an increasingly competitive environment. Creative thinking is not limited to art or design but is also highly relevant across various fields such as business, education, and technology. Therefore, creative thinking is considered vital in education and in the personal development of individuals.

In the field of mathematics education, various literature analyses have revealed that *creativity* encompasses multiple aspects (Mann, 2006; 2009; 2016; Sriraman, 2006). However, four components of creativity are frequently used in the literature: fluency**,** flexibility**,** originality**,** and elaboration. Meanwhile, other studies in mathematical creativity literature identify only three components: fluency**,** flexibility**, and** originality (Torrance, 1969; Haylock D, 1997; Kim et al., 2003; Siswono, 2018). *Fluency* refers to the number of relevant responses generated by an individual, reflecting their ability to produce numerous ideas and explore various possibilities for solving a problem (Mann, 2016). *Flexibility* refers to an individual's ability to think about a problem using a variety of approaches when generating responses. *Originality*, in turn, refers to the uniqueness of the ideas produced in response to a given question. This study focuses on three aspects of creativity: fluency, flexibility, and novelty. These components are highly relevant in mathematics education, as mathematics is not solely about finding a single correct answer, but also about encouraging students to explore multiple problem-solving strategies. Creativity in mathematics involves the ability to think outside the box, form new associations, and connect seemingly unrelated concepts. This allows students to discover unconventional approaches and innovative solutions to mathematical problems (Leikin & Pitta-Pantazi 2013). Which states that creativity in mathematics involves the ability to explore multiple solution paths, make connections between diverse ideas, and think in a flexible and original manner. Moreover, creativity supports students in developing a deeper understanding of mathematical concepts and enhances their abstract thinking skills (Putri et al., 2024).

Each student has a different way of solving mathematical problems, as their thinking abilities vary. In one of Hadamard’s works, mathematical thinking is described as either *logical*—that is, thinking that follows conventions, routines, or specific procedures—or *intuitive* (Mann, 2016). The process of creative thinking is a result of the combination between logical thinking and divergent thinking. *Divergent thinking* helps students generate multiple ideas for solving problems, while *logical thinking* allows them to evaluate and refine those ideas. Furthermore, according to Gardner (1983) in his *Theory of Multiple Intelligences*, logical-mathematical intelligence includes the ability to think systematically, analyze patterns, and solve problems using logic and reasoning.

Students with logical-mathematical intelligence tend to excel in understanding mathematical concepts, identifying relationships between variables, and developing structured solutions. In addition, they are capable of designing effective problem-solving strategies. According to Gardner (1983), individuals with logical-mathematical intelligence possess the ability to analyze problems logically, perform mathematical operations, and investigate issues scientifically. These characteristics are particularly essential in learning the topic of function composition, which requires a deep understanding of patterns and relationships between functions. In general, students with logical-mathematical intelligence demonstrate strong analytical abilities, systematic thinking, and the capacity to recognize patterns and relationships within a problem. They are typically more comfortable using logic-based approaches, symbols, and numbers in solving mathematical problems (Oktaviani, 2020).

According to DePorter and Hernacki (2008); Munandar (2014,) learning style refers to an individual's tendency in receiving, absorbing, and processing information. Therefore, it becomes an important variable in how students understand concepts and solve mathematical problems. Fleming and Mills (1992) classified learning styles into three categories: visual, auditory, and kinesthetic. The visual learning style helps students understand information through images, diagrams, and graphic representations. The auditory learning style is more effective for students who comprehend material through discussions and verbal explanations. Meanwhile, the kinesthetic learning style involves direct activities and physical experiences in understanding concepts.

Function composition involves more than one function; when one function is followed by another, it forms a new, composite function (Ananda Geno et al., 2024). In addition, students with logical-mathematical intelligence tend to have greater potential in understanding the operations involved in function composition. However, differences in learning styles may influence how they construct solutions (Azinar et al., 2020). A student with a visual learning style may better grasp the concept through diagrams or graphs. An auditory learner might benefit more from discussions and verbal explanations. Meanwhile, a kinesthetic learner tends to understand the concept more effectively through hands-on exploration, such as manipulating symbols or using concrete learning tools (Honey & Mumford, 1986).

The researcher believes that a deeper understanding of the relationship between logical-mathematical intelligence, learning styles, and creative thinking in the context of function composition will help enhance the effectiveness of instruction and provide valuable insights for educators in designing more adaptive teaching methods. However, not all students with logical-mathematical intelligence demonstrate the same level of creative thinking. Some students may excel in fluency, while others may show greater strength in flexibility or novelty. Therefore, it is important to analyze the creative thinking profiles of students with logical-mathematical intelligence in solving mathematical problems, viewed through the lens of their learning styles. By understanding these differences, educators can develop more effective instructional strategies tailored to the unique characteristics of each student.

Several previous studies have examined the relationship between logical-mathematical intelligence and creative thinking skills. Oktaviani (2020) found that students with logical-mathematical intelligence tend to be able to develop problem-solving strategies in mathematics in a systematic and logical manner. However, the study did not explore in depth the variations in students' creative thinking profiles based on different learning styles. Another study by Azinar et al. (2020) showed that learning styles influence how students understand mathematical concepts, but it did not investigate the relationship between learning styles, logical-mathematical intelligence, and the dimensions of creative thinking in the context of solving function composition problems. The research gap is evident in the lack of studies that integrate all three variables—logical-mathematical intelligence, learning styles, and creative thinking—simultaneously within mathematics learning. Most studies have focused only on two variables, thus failing to provide a comprehensive picture of how the three interact in the process of mathematical problem-solving, particularly in the topic of function composition, which requires abstract, logical, and creative thinking skills. It is still commonly found that students' mathematical problem-solving abilities remain lacking, especially in higher-order thinking aspects such as creative thinking. This highlights the need for a more adaptive instructional approach that considers students' individual characteristics in order to optimally develop their creative thinking potential. Based on this background, the research question proposed is " what is the creative thinking profile of students with logical mathematical intelligence in solving function composition problems when viewed from perpective of learning styles?"

Methods

This research is a qualitative descriptive study employing a qualitative approach. A qualitative approach was chosen because it allows for an in-depth exploration of students' creative thinking processes within real-life contexts. According to Creswell (2012), this approach is well-suited for gaining a comprehensive understanding of individuals' meanings and experiences. The purpose of this study is to develop a profile of creative thinking in 10th-grade students with logical-mathematical intelligence when solving mathematical problems, viewed from the perspective of their learning styles. The research subjects consist of three students, each representing logical-mathematical intelligence. Additionally, each of the three subjects possesses a different learning style. Subject selection was carried out using a Logical IQ Test, which included number analogies, number sequences, and word problems, administered to all 10th-grade high school students. The instrument used in this study was the *Psychology Test* digital platform, which was designed to measure logical-mathematical intelligence. The platform contains tests that assess students' abilities to recognize patterns, solve problems, and think logically. To validate the instrument, content validation was conducted by involving educational psychology experts to ensure that the test items accurately represented the intended constructs. The test consists of questions designed to evaluate logical reasoning and analytical skills, with result reports that reflect students' logical abilities in Figure 1.

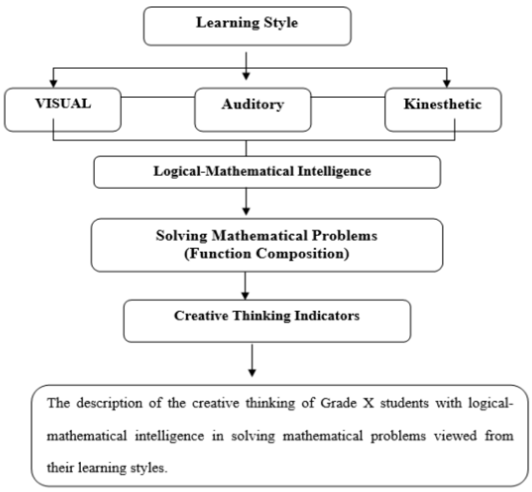

Figure 1. Framework of Thinking in the Study

Results and Discussion

The selection of research subjects in this study began with the administration of a Logical IQ Test, aimed at identifying students with logical-mathematical intelligence. The test was taken by 272 Grade 10 students from both science and social studies tracks. Students completed the test directly through https://www.psychologytoday.com/us/tests/iq/logic-iq-test, and the test lasted for 90 minutes. The test results showed that 13 students demonstrated logical-mathematical intelligence. These students were then given a learning style questionnaire. The results of the Logical IQ Test and the learning style questionnaire are presented in Table 1.

Table 1. Students with Logical-Mathematical Intelligence and Their Learning Styles

Student Initials	Report on the Results of the Logical IQ Test	Learning Style
DP	Your Score on The Test Was Quite Satisfactory. Indicating That You Have Solid Foundation of Logical Thinking Skills	Kinesthetic
RS		Visual
NL		Visual
MD		Kinesthetic
FD		Auditory
MF		Auditory
AJ		Visual
WA		Visual
FR		Auditory
DV		Visual
MH		Visual
DA		Kinesthetic
NS		Auditory

Table 1 shows that 13 students demonstrated strong logical thinking skills, as reflected in their satisfactory test scores. This indicates that these individuals have a solid foundation in logical reasoning, which is one of the core components of logical-mathematical intelligence. From this group, three students were selected as research subjects, as presented in Table 2. These subjects were assigned the initials RS, MD, and FD.

Table 2. Subject Selection

No	Student Initials	Report on the Results of the Logical IQ Test	Learning Style
1	RS	Your score on the test was quite satisfactory. Indicating that you have solid foundation of logical thinking skills.	Visual
2	MD		Auditory
3	FD		Kinesthetic

Subsequently, the three subjects who met the criteria in Table 2 were given a function composition task, as illustrated in Figure 2.

A home-based bakery produces cakes through two stages of production using 10 kg of raw materials (x) every day. In the first stage, the dough is made and expressed by the function $g(x) = 2x + 1$. After that, the dough is baked, which is expressed by the function $f(x)$. The total number of cakes produced after both stages is given by $(fog)(x) = 4x^2 + 10x - 3$, which is 497 cakes. If the bakery wants to increase cake production by changing the dough function to $g(x) = 2x + 5$, how many cakes will be produced after both stages?

Figure 2. Function Composition Task

The Creative Thinking of a Student with Logical-Mathematical Intelligence and a Visual Learning Style in Solving Function Composition.

1. Understanding the Problem

The subject was asked to understand the function composition task. After reading the task, the subject stated that they had understood it. They identified all the elements contained in the task—for example, the given information such as the raw materials used, the dough function, and the baking function. In addition, they also mentioned the question being asked. To gain deeper insight, the researcher asked the subject to write down their understanding. The subject's written response is shown in Figure 2 below.

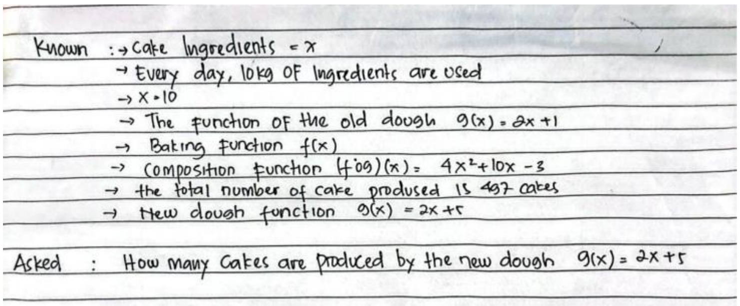
Known : → Cake Ingredients = x
→ Every day, 10kg OF Ingredients are used
→ x = 10
→ The function OF the old dough g(x) = 2x + 1
→ Baking function f(x)
→ Composition function (fog)(x) = 4x² + 10x − 3
→ the total number of cake prodused is 497 cakes
→ New dough function g(x) = 2x + 5
Asked : How many Cakes are produced by the new dough g(x) = 2x + 5

Figure 2. RS's Response

Based on Figure 2, the aspects of fluency and flexibility. Fluency is demonstrated when subject RS wrote down several functions and was able to distinguish between different pieces of information. The subject noted that the given information did not contain a question mark, whereas a question should include one. An excerpt from the interview with subject RS regarding this can be found in Table 3.

Table 3. Interview Excerpt from Subject RS on the Aspect of Fluency

Subject	Interview
PE	Do you understand this task?
RS	Yes, Miss
PE	Please explain
RS	the raw materials are known and assumed to be $x = 10$, that dough function $g(x) = 2x + 1$ then the baking function $f(x)$, its composition function $(fog)(x) = 4x^2 + 10x - 3$, A total of 497 cakes were produced, and the new dough function is defined as follows $g(x) = 2x + 5$. The question asks for the number of cakes produced by the new dough function $g(x) = 2x + 5$
PE	What is x in this context?
RS	The cake's raw material, miss
RS	A composition function is a combination of two functions.
PE	Okay. How did you figure out what information was given and what was being asked in the problem?
RS	The question can be identified by the presence of an interrogative sentence or a question mark. (while pointing to the sentence starting with "how many…" in the question*l*). Whereas the given information does not contain a question mark.

The flexibility aspect is evident when RS was able to interpret the problem in different ways. Subject RS did not merely read the question at face value but also made an effort to understand the context of the problem and how the given functions were interrelated. RS understood how changes in a function would affect the final result and was able to connect various pieces of information presented in the problem—for example, the individual functions and the composite function. The following is an excerpt from the interview regarding the flexibility aspect, presented in Table 4.

Table 4. Interview Excerpt from Subject RS on the Flexibility Aspect

Subject	Interview
PE	What do you understand from this task?
RS	Hmm (reading the notes he made) This is a problem about a cake shop, miss. From what I read, the cake shop makes cakes through two stages.
PE	What do you mean by stages?
PE	The first stage is making the dough, using the function $g(x) = 2x + 1$. Then, the dough is baked in the second stage, using the function $f(x)$. *The* final output is determined using the composite function $(fog)(x) = 4x^2 + 10x - 3$, with a total of 497 cakes produced when 10 kilograms of raw materials are used.

2. Devising A Plan

When subject RS was formulating the solution plan, aspects of fluency, flexibility, and novelty emerged. Fluency was evident as RS clearly and logically explained the steps that would be used. Flexibility appeared when RS described three different methods to solve the problem. RS's originality was shown when he considered assigning a symbol to f(x) in the form of a quadratic equation, even though this method had not been taught previously.

He also identified patterns and tried new approaches to solve the problem, demonstrating the courage to seek alternative solutions. The planning stage is shown in Figure 3.

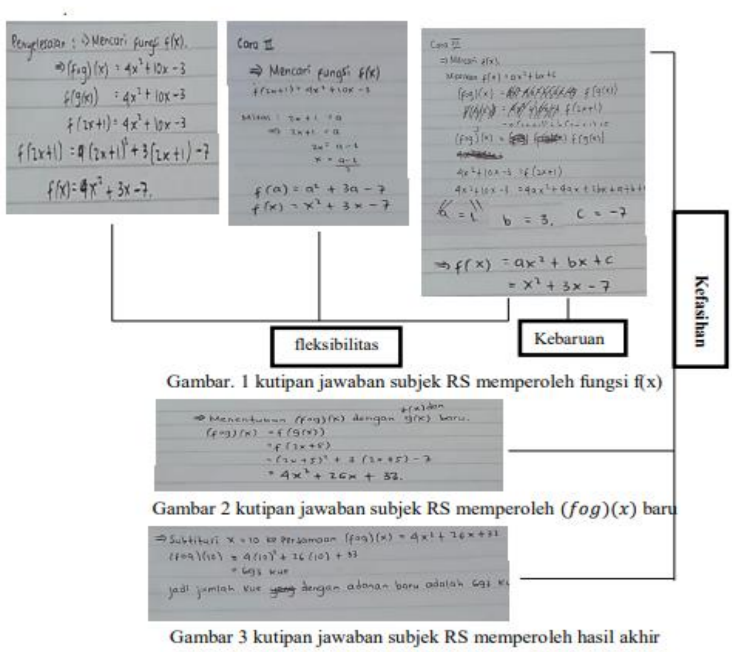

Figure 3. Subject RS in Planning and Implementing the Plan

The following is an excerpt from the interview with the subject, where the researcher explored the findings related to the aspects of fluency, flexibility, and novelty as presented in Table 5. In formulating the plan, fluency is demonstrated by RS's clear and logical explanation of the steps to be taken. Flexibility is evident when RS describes three different methods that will be used to solve the problem. RS's originality appears when he considers representing f(x) as a quadratic equation, even though this method has not been previously taught. He also identifies patterns and tries new approaches to solve the problem, showing courage in seeking alternative solutions.

Table 5. Interview the Subject on the Aspects of Fluency, Flexibility, and Novelty

Subject	Interview
RS P	What did you use to solve this problem? Please explain.
RS S	Hmmm (while looking at the notes that were made) First, I tried to find the function $f(x)$ using the formula of the composition functioni $(fog)(x)$. After determining the function $f(x)$ I composed it again with the new function *g(x)* Then, I substituted the value $x = 10$ into the new composition function $(fog)(x)$
RS P	Okay. Is there another way, besides this one, to solve the problem in the question?
RS S	Just like in Method I, Ma'am, I first found $f(x)$ But in Method II, I used the inverse function to obtain $f(x)$
RS P	Is there another method besides these two ways of solving the problem?
RS S	No, Ma'am, I haven't learned it before. But after thinking it through and trying it out, I realized I could use this method to find $f(x)$. Once I had$f(x)$ I could directly find its composition with $g(x)$. After that, I substituted the value $x = 10$ and obtained the total number of cakes.

3. Carrying Out the Plan

Next is an excerpt from the interview with subject RS, in which he explains the steps for solving the problem, demonstrating the aspect of fluency, as shown in Table 6.

Table 6. Interview Excerpt with the Subject on the Aspect of Fluency

Subject	Interview
RS P	Could you explain your solution method?
RS S	Yes, Ma'am. In the first method, I started by finding the value of $f(x)$ I used the composition formula so it becomes $f(g(x)) = 4x^2 + 10x - 3$ Since $g(x)$ s already known.
RS P	Before we continue, I'd like to ask—what made you think of using this method?
RS S	During the lesson on composition functions, we were once taught to find $f(x)$ using this method.

Flexibility was demonstrated by RS through the use of three different methods to solve the problem: substituting variables, applying the concept of inverse functions, and assuming the function $f(x)$ in quadratic form. All methods produced consistent results. An excerpt from the interview with subject RS is presented in Table 7 below.

Table 7. Interview with Subject RS on the Aspect of Flexibility

Subject	Interview
RS P	Okay. Is there another method besides this one to solve the problem in the question?
RS S	yes Ma'am, I first found $f(x)$ But in Method II, I used the inverse function to determine $f(x)$
RS P	Okay. What made you think of that method?
RS S	I've been taught that before, Ma'am. Next, I used this method when learning about composition functions. (proceeds directly to solving the problem)
PE	Why does it have to be substituted?
	(Continues solving the problem first, then gives a further explanation) Like this, Ma'am $\left(\frac{a-1}{2}\right)^2$ by using the method $\frac{(a-1)^2}{2^2} = \frac{a^2-2a+1}{4}$ (*pointing to the scratch work*) then I multiplied it by 4 again, so the result is.. $a^2 - 2a + 1$ Then I calculated this part again, Ma'am. (while showing $10(\frac{a-1}{2})$. Next, divide 10 by 2 and multiply it by ... so the result is obtained $5\ (a-1)$. Then, proceed with the multiplication $5 \times a$ dan $5\ \times (-1)$.
RS S	Because I've already found $f(x)$nya . It's the same as Method I, I just need to compose the functions. $f(x)\ dan\ g(x)$ the new one. Next, substitute $x = 10$
RS S	Yes, Ma'am. (continues solving) The result is 693 cakes, Ma'am

Originality was shown by RS, who was able to use a different method from others to solve the problem by assuming a function $f(x) = ax^2 + bx + c$. The following is an excerpt from the interview with subject RS in Table 8.

Table 8. Interview with Subject RS on the Aspect of Originality

Subject	Interview
RS WP	Is there any other way besides the two methods you used earlier?
RS WS	This third method still involves finding $f(x)$ first. This process involves assuming $f(x) = ax^2 + bx + c\ f(x)\ dan\ g(x)$) are composed, just like before.
RS WP	Have you ever learned this method before?
RS S	Not yet, Ma'am. But after I thought about it and tried it, I realized it might work to use this method to find f(x). Once I found it, I could directly compose it with the new $g(x)$ hen substitute $\mathrm{x} = 10$ and I got the number of cakes.

4. Looking Back

During the review stage, RS demonstrated aspects of fluency and flexibility. Fluency was evident as RS was able to clearly express the conclusion of their work. The following is an excerpt from the interview with subject RS, presented in Table 9.

Table 9. Interview Excerpt with Subject RS

Subject	Interview
RS P	Okay. Are you confident with your answer?
RS S	Yes, I'm confident. I've already repeated the process, and there are 963 cakes produced**.**

Flexibility was demonstrated by RS through the ability to review the formulas and methods used to solve the problem. RS ensured the accuracy of the answer by carefully rechecking each step of the solution process. The following is an excerpt from the interview with subject RS, presented in Table 10.

Table 10. Interview Excerpt with Subject RS on the Aspect of Flexibility.

Subject	Interview
RS P	How did you recheck your solution?
RS S	I reviewed each step carefully, Ma'am, and I did the calculations twice. The result was still the same as what I got before.

Creative Thinking of Students with Logical-Mathematical Intelligence and Auditory Learning Style in Solving Composition Function.

1. Understanding the Problem

After reading the composition function task, the subject stated that they had understood the task. They identified all the elements included in the problem. The details were then written down as shown in Figure 4 below.

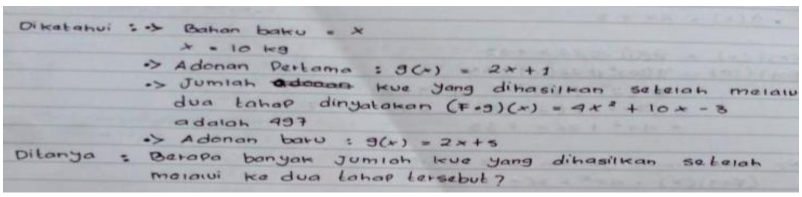

Figure 4. Excerpt of MD's Answer

Based on Figure 4, aspects of fluency and flexibility are evident. When subject MD accurately and fluently conveyed the known and asked information, this reflects fluency. MD explained that the reason behind identifying the known and asked information was that the known information refers to data or details explicitly provided in the problem, while the asked information refers to what is required to be found or solved based on the problem. The following is an excerpt from the interview with subject MD presented in Table 11.

Table 11. Interview Excerpt with Subject MD on the Aspect of Fluency

Subject	Interview
MD S	Yes, I can, Miss. What's given is (while writing) the raw material, x
MD P	What does raw material x mean?
MD S	Let's assume the raw material is x so $x = 10$ kg. The first dough function is $g(x) = 2x + 1$, The number of cakes produced after two stages is represented by (($(fog)(x) = 4x^2 + 10x - 3$ which results in 497 cakes.
MD P	Okay, how do you know which parts are the given information and which are being asked?
MD S	It's clear, Miss… what's being asked is what the problem wants us to find, while the given information is what's already provided in the question.

Next, flexibility was demonstrated when subject MD interpreted the problem in a different way. The subject was also able to logically explain the main elements and recalculate the result based on the change in the function. In addition, the subject was able to connect the given information with the context of the problem. The following is an excerpt from the interview with subject MD, presented in Table 12.

Table 12. Interview Excerpt with Subject MD on the Aspect of Flexibility

Subject	Interview
MDP	Were you able to understand the question?
MDS	The problem is about a cake shop that uses 10 kg of raw ingredients each day. In the first stage, the dough is made using the formula $g(x) = 2x + 1$, hen baked using the formula $f(x)$ and the result is 497 cakes.
MDS	So, the raw material is $x = 10\ kg$. There are two stages in the cake-making process: the first stage is mixing the dough using the function $g(x) = 2x + 1$, and the second stage uses the function $f(x)$. The final result from the two stages using the original function composition $(fog)(x) = 4x^2 + 10x - 3$ is 497 cakes.

When planning the solution, MD demonstrated both fluency and flexibility. Fluency was evident as MD outlined a clear, logical, and structured plan for solving the problem. Flexibility was shown through MD's ability to explain two different methods to solve the problem, both of which had been previously learned or taught during classroom instruction.

2. Devising A Plan

During the planning stage, aspects of fluency and flexibility emerged. Fluency was evident as MD formulated a clear, logical, and structured plan for solving the problem. Flexibility was demonstrated through MD's ability to explain two different methods to solve the problem, which had previously been learned or taught during classroom instruction. The planning stage is shown in Figure 5 below.

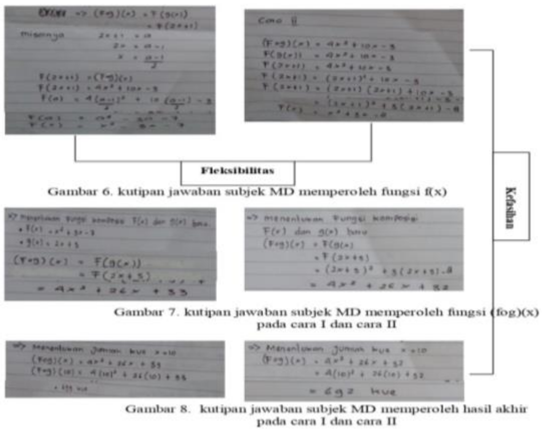

Figure 5. Subject MD in Planning and Carrying Out the Solution

The following is an excerpt from the interview with the subject, highlighting the findings on fluency and flexibility as presented in Table 13.

Table 13. Subject MD on the Aspects of Fluency and Flexibility

Subject	Interview
MD W1 39 P	Okay, what's your plan to solve it?
MD W1 40 S	First, Ma'am, I will determine the function $f(x)$ from the composition function and the given $g(x) = 2x + 1$ After obtaining $f(x)$, I will replace the $g(x)$ with the new dough function. That way, the new function composition can be determined. Finally, I will substitute $x = 10$ to find the number of cakes.
MD W1 71 P	Okay… do you think there's another way?
MD W1 72 S	Yes, Ma'am. But I'll try it first, Ma'am.
MD W1 74 S	I still need to find $f(x)$ Ma'am, using the given composition function $(fog)(x) = 4x^2 + 10x - 3$ Then, I'll substitute $g(x) = 2x + 1$ into $f(x)$ even though $f(x)$ is still unknown.

3. Carrying Out the Plan

The following is an excerpt from the interview with subject MD during the implementation stage, which highlights the aspect of fluency. Fluency was demonstrated by MD's ability to clearly and smoothly explain the results of their work in a structured manner for each method used to solve the problem. The first method resulted in an answer of 693 cakes, while the second method produced 692 cakes. MD recognized the difference in outcomes between the two methods. The interview excerpt related to fluency is presented in Table 14.

Table 14. Interview Excerpts with Subject MD on the Aspect of Fluency

Subject	Interview
MD P	What process did you follow?
MD S	Yes, I have, Ma'am.
MD S	I simplified $f(a)$ ike this, Ma'am (showing the steps of simplifying $f(a)$). I squared the expression $\left(\frac{a-1}{2}\right)$ first, which resulted in $\frac{a^2-2a+1}{4}$ Then I multiplied it by 4, so it became $\frac{4a^2-8a+1}{4}$ and then divided it again by 4 to get $a^2-2a+1\left(\frac{a-1}{2}\right)$ After that, I multiplied $\frac{10a-10}{2}$ and again it became $5a-5$.
MD S	I converted the function in terms of a back to a function of x Ma'am, so it became $f(x)=x^2+3x-7$. So now we've got $f(x)$. Now we find the new composition, but this time with $g(x)$= $2x+5$
MD S	Hmm… I substituted $x=10$ into the composition function to find the number of cakes.
MDS	here it is, Ma'am, x is replaced with 10, so the expression become $4(10)^2+26(10)+33$ which simplifies to 693 cakes. This is the final result.

Flexibility was demonstrated by MD's ability to switch methods, as MD was not fixated on a single approach to solving the problem. MD employed two different methods to solve the problem: using the concept of inverse functions and substituting variables. Both methods had been previously learned. The following are interview excerpts with subject MD regarding the aspect of flexibility, presented in Table 15.

Table 15. Interview with Subject MD on the Aspect of Flexibility

Subject	Interview
MD P	Okay. Is there another method you could use to solve this problem?
MD S	es, Ma'am. That method was also taught, the one where we adjust the form of x . But I'll try it out first, Ma'am.
MD S	I still need to find $f(x)$ d first, Ma'am, using the help of the known composition function, $(fog)(x) = 4x^2+10x-3$ Then I'll substitute it into $g(x)=2x+1$ to $f(x)$ Even though $f(x)$ is not known yet, we'll adjust it later to match $2x+1$ bu.
MD S	es… once we've found $f(x)$ then we can find the function composition using the same method as in method one, and then find the number of cakes using method one as well.
MD S	First, we write the function composition $(fog)(x) = 4x^2+10x-3$ We use $(fog)(x) = f\big(g(x)\big) = 4x^2+10x-3$ as a guide.
MD S	(Continuing the composition of functions)) I got the function as $(fog)(x)=4x^2+26x+32$. After that, I continued by substituting $x=10$

4. Carrying out the plan

During the review stage, MD demonstrated aspects of fluency and flexibility**.** Fluency was evident as MD showed the ability to clearly express the conclusion of their work. The following is an excerpt from MD's interview related to the aspect of fluency in Table 16**.**

Table 16. MD's interview on the aspect of fluency

Subject	Interview
MD P	Alright. Are you sure about your answer?
MD S	Yes, I'm sure, Ma'am. So the number of cakes produced after changing to the new dough, or $g(x) = 2x + 5$ is 693 cakes. There's an increase, Ma'am.
MD S	$4(10)^2 + 26(10) + 32,$ 10 squere 2 equals 100, 26 kali 10 equals 260 plus 32 so 4(100) + 260 + 32, 4 kali 100 equals 400 plus 260 plus 32 equals 692 cake.

Flexibility was demonstrated by MD through the ability to review the formulas and methods used to solve the problem**.** In the second method, MD noticed a discrepancy in the result compared to the first method. He then re-examined the steps he had taken, carefully tracing each calculation step from both approaches. MD identified an error in the calculations of the second method. Upon finding the mistake, he corrected the calculation and arrived at a consistent result. An excerpt from MD's interview related to the aspect of flexibility is presented in Table 16.

Table 16. Interview excerpt of subject MD demonstrating flexibility

Subject	Interview
MD P	Where do you think the error happened in method one or method two?
MD S	Let me check it again, Ma'am**.**
MD P	Did you find it?
MD S	Oh, it's here, Ma'am — in the second method. I made a mistake when multiplying 1 in the expression $(2x + 1)(2x + 1)$.

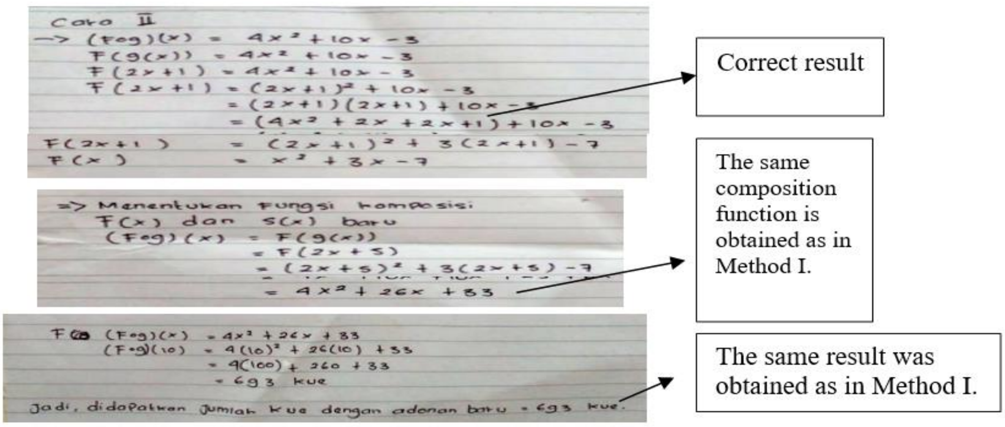

Figure 6. Revised Answer by Subject MD

Creative Thinking of Logico-Mathematical Intelligence Students with a Kinesthetic Learning Style in Solving Composition Function.

1. Understanding the problem

After reading the task on function composition, the subject stated that they had understood the task. They identified all the elements contained in the problem. The details were then written down as shown in Figure 9 below.

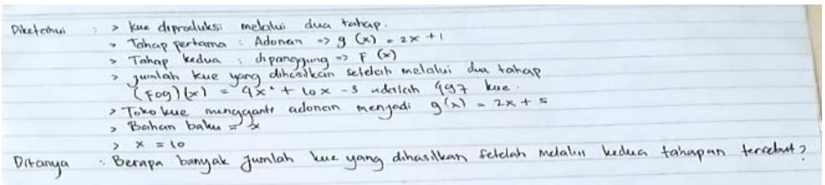

Figure 7. Excerpt of FD's Answer

Based on Figure 9, aspects of fluency and flexibility can be observed. Fluency is evident as FD was able to express and write down the known and the required information from the given problem. FD understood that the known information comes directly from the problem text and does not need to be searched further, while the required information refers to what needs to be solved. The excerpt of the interview with subject FD is presented in Table 17.

Table 17. Interview with Subject FD on the Aspect of Fluency

Subject	Interview
FD P	How were you able to distinguish between the given information and what is being asked?
FD S	Hmm… I know it's the given information because it's already provided in the problem and doesn't need to be found.

Furthermore, flexibility is demonstrated by FD's ability to provide multiple interpretations of the problem, attempt to substitute values for x in the composition function to explore the relationship between each function, and use the analogy of the cake-making process to understand the concept. The interview excerpts with subject FD are presented in Table 18.

Table 18. FD's Interview on the Flexibility Aspect

Subject	Interview
FD P	Can you explain what you understand?
FD S	The composition of the functions $g(x)$ and $f(x)$ results in $(fog)(x) = 4x^2 + 10x - 3$
FD S	Based on my understanding, the composition function in this problem, ilar to the steps of making a cake in the bakery. The first stage is the dough-making process represented by the function $g(x)$, followed by the baking process represented by the function $f(x)$.

2. Devising A Plan

During the planning phase, FD exhibited indicators of fluency, flexibility, and originality. Fluency was reflected in FD's ability to convey the problem-solving steps in a clear and organized manner, accompanied by occasional physical gestures. Flexibility emerged as FD proposed three alternative approaches to solving the problem. Originality was evident in FD's ability to generate a unique strategy that differed from previously taught or commonly adopted methods.

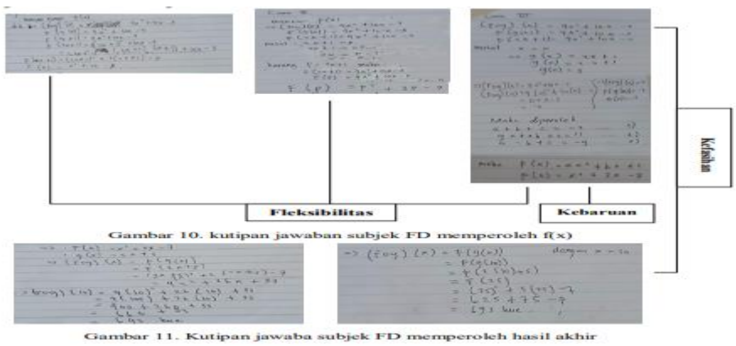

Figure 8. Subject RS During the Planning and Implementation Stages

The following is an excerpt from the interview with subject FD during the planning stage, which demonstrates fluency, flexibility, and originality. The interview excerpt is presented in Table 19.

Table 19. Subject FD on the Aspects of Fluency, Flexibility, and Originality

Subject	Interview
FD P	Okay, what is your plan to solve the problem?
FD S	I'll find $f(x)$ first, Ma'am, because I want to compose it with $g(x) = 2x + 5$ using the known composition function $(fog)(x) = 4x^2 + 10x - 3$ as a reference, After obtaining $f(x)$ I will then compose it with $g(x) = 2x + 5$
FDP	Okay... do you think there is another way to solve this problem?
FDS	Yes, ma'am, by using the inverse method
FDP	Alright, is there any other alternative method to solve this problem?
FDS	Yes, Ma'am. I solved it by assuming the values like this.

3. Carrying Out The Plan

Next, during the implementation stage, FD demonstrated aspects of fluency, flexibility, and originality. Fluency was evident as FD was able to clearly explain the results of the work in a structured manner. The following are excerpts from the interview in which the subject FD explained the steps for solving the problem, as shown in Table 20 below.

Table 20. Subject FD on the Aspect of Fluency

Subject	Interview
FDP	Alright, could you please explain the steps you followed to solve the problem?
FDS	Yes, Ma'am, I can. First, I found $f(x)$ using the information from $(f \circ g)(x) = 4x^2 + 10x - 3$. I substituted $g(x)$ into $f(x)$. because $g(x) = 2x + 1$, So the form becomes $f(2x + 1) = 4x^2 + 10x - 3$. Now, because here (pointing to $f(2x + 1)$) and here (pointing to $4x^2 + 10x - 3$) There is only the variable x, o I have to adjust it, Ma'am, to make the form match $2x + 1$.
FD P	Change it into what?
FD S	Finding the composition of the functions $f(x) = x^2 + 3x - 7$ and $g(x) = 2x + 5$ ma'am
FDS	Yes, Ma'am. (starts working) So, Ma'am, it's 4 times 10 squared, plus 26 times 10, plus 33. That means 4 times 100 equals 400, 26 times 10 is 260, plus 33. Hmm… 400 plus 260 is 660, plus 33 is 693. It's done, Ma'am… so the result is 693 cakes

Flexibility was demonstrated by FD's ability to switch strategies. FD employed three different methods to solve the problem: substituting variables, using the concept of inverse functions, and assuming the form of each function. All of these approaches produced consistent results. The following are excerpts from FD's interview in which they explained alternative methods used to solve the problem, as shown in Table 21.

Table 21. FD's Interview on the Aspect of Flexibility

Subject	Interview
FDP	Okay, can you explain the steps to me?
FD P	Could you explain it to me, Ma'am?
FD S	es, Ma'am. First, I performed the composition by substituting $g(x)$ into $f(x)$, So I obtained $f(2x+1) = 4x^2 + 10x - 3$. Well, since there is $2x+1$, I inverted this function, Ma'am. The method I used was by assuming $2x+1 = p$. Then, I subtracted 1 from both sides, resulting in $2x = p - 1$. After that, I divided both sides by 2 to find x, which resulted in $x = \frac{p-1}{2}$. After this, I continued again, Ma'am.
FD P	okay, to find the number of cakes?
FD S	I composed $f(x) = x^2 + 3x - 7 \; dan \; g(x) = 2x + 5$, Ma'am, but I directly substituted the value $x = 10$. After the calculation, the final result was 693, Bu.

Originality was demonstrated by FD through the use of a novel approach by assuming values of x = 0, 1, and -1 to calculate function values and construct a system of linear equations. From this process, FD was able to determine the function f(x). Subsequently, FD calculated f(g(10)) and obtained a result of 693. Table 22 presents excerpts from the interview with FD, highlighting the use of a novel approach in solving the problem.

Tabel 22. FD subject interviews on the aspect of novelty

Subject	Interview
FD P	Okay, is there any other different method you can use to solve the problem?
FD S	Yes, Ma'am. Here's how I approached it by making some assumptions.
FD S	$x$for $g(x)$and $(fog)(x)$
FD S	First, I assumed x =0 , then I substituted it into $g(x)$ to find $g(0) = 1$ Then I continued to $(fog)(x) = 4x^2 + 10x - 3$ since I already have all the values, right Bu? I used the same method as the first one until I got the result. $(3) = 11$. Then I tried another value $x = -1$ until I got $f(-1) = -9$
FD P	Okay, have you ever been taught this method before?
FD S	No, Ma'am. I figured it out myself, hehe.
FDS	I found the function composition, Ma'am, using the same method as in method II. I composed the functions and directly substituted the value x = 10. The result was 693 cakes.

During the review stage, MD demonstrated aspects of fluency and flexibility. Fluency was evident as FD showed the ability to clearly express the conclusion of the solution. The following is an excerpt from the interview with subject FD, in which they confidently presented the conclusion of their answer, as shown in Table 23.

Table 23. Interview with Subject FD on the Aspect of Fluency

Subject	Interview
FD P	How can you be sure?
FD S	I'm confident because the result is the same 963 cakes, Ma'am.

Flexibility was demonstrated by FD through the ability to review the formulas and methods used to solve the problem. FD verified the function $f(x)$ by composing it with $g(x) = 2x + 1$, o ensure the result matched the formula $(f \circ g)(x) = 4x^2 + 10x - 3$. FD also demonstrated carefulness in checking the calculation steps for the number of cakes, showing a high level of attention to detail in ensuring the accuracy and consistency of the results. The following is an excerpt from FD's interview while reviewing the formulas in Table 24.

Table 24. Subject FD interviews on flexibility

Subject	Interview
FD W1 130 S	I also verified the correctness of the obtained function $f(x)$ by performing the composition with $g(x) = 2x + 1$ and it resulted in the original composition function, confirming that $(fog)(x) = 4x^2 + 10x - 3$ was accurate That means the $f(x)$ I obtained is correct.
FD W1 131 P	Okay. Have you checked the third method as well? There might be a mistake
FD W1 132 S	Yes, I have reviewed it, Ma'am. I recalculated the substitutions. Then, when I changed the values, the result still remained the same

The results of this study indicate that RS demonstrated more than one aspect of creative thinking. This ability is supported by RS's strong logical-mathematical intelligence, characterized by analytical thinking, understanding of abstract concepts, and problem-solving based on logic. This form of intelligence enabled RS to grasp the structure of functions and their compositions, in line with the statement by Alfi'a and Maknunah (2019), who assert that logical-mathematical intelligence encompasses the ability to think inductively, deductively, and to analyze numerical relationships.

RS's visual learning style supported the ability to organize information in a structured manner. According to DePorter & Hernacki (2008), visual learners tend to be organized individuals. In the composition task, RS identified key elements such as the raw materials, the mixing function, the baking function, the composition function, the number of cakes (497 cakes), and the new mixing function as part of the given and asked information. RS also used sketches and diagrams to visualize the relationships between functions. This aligns with Fauzan and Lubis (2020) explanation that visual learners better comprehend written or graphical information. Fluency was evident in RS's ability to accurately and fluently articulate the information, consistent with Ekayana, et al (2020) view. Flexibility was shown in RS's ability to interpret the problem in various ways, which reflects Mardhiyana and Sejati (2018) findings that flexibility involves viewing a problem from multiple perspectives. RS was also able to formulate problem-solving steps logically, clearly, and structurally, in line with Polya's theory (1957).

RS demonstrated aspects of creative thinking: fluency, by articulating the solution steps clearly and proposing more than one method; flexibility, by applying three different approaches including one unfamiliar from classroom instruction; and novelty, by constructing a new solution through hypothesizing a quadratic function based on patterns identified in previous methods. RS also exhibited a willingness to experiment and creativity, which aligns with (Sternberg and Lubert's, 1995; Asmidi, 2021). Then assertion on the importance of alternative strategies and unconventional solutions in problem-solving. RS successfully tackled the problem using logical-mathematical intelligence, a sound understanding of function composition, and the ability to analyze problems through multiple strategies.

The subject MD demonstrated strong abilities in identifying and organizing the information presented in the problem in a structured manner. MD was able to comprehend the relationships between functions, analyze the interconnections among problem elements, and adjust strategies according to the conditions of the problem. This is supported by MD's logical-mathematical intelligence, which enables analytical, inductive, and deductive thinking, as well as an auditory learning style that facilitates understanding through reading aloud and verbal explanation.

MD's auditory learning style supported the subject in articulating the problem verbally in a fluent and in-depth manner, consistent with the characteristics of auditory learners as described by DePorter & Hernacki (2008). At the problem-understanding stage, MD demonstrated two aspects of creative thinking: fluency, by expressing all the information in the problem clearly and accurately, as supported by Ekayana et al., (2020); and flexibility, by offering various interpretations of the problem, aligning with the characteristics of flexibility described by Munandar (2009). MD was also able to formulate a problem-solving plan with clear, logical, and structured steps.

MD proposed two alternative solutions—using the inverse function and the composition function formula—demonstrating the ability to think logically, analytically, and flexibly, in accordance with the characteristics of logical-mathematical intelligence as described by Gardner (1983). MD's coherent explanations and ability to offer more than one solution reflect both fluency and flexibility. Fluency is evident in MD's smooth articulation of the solution plan and in presenting alternative approaches based on previously taught methods. Flexibility is shown through the ability to apply various problem-solving strategies. This ability is further supported by MD's auditory learning style, which facilitates better comprehension and verbal explanation of problems.

MD's auditory learning style supports the ability to recall alternative methods previously explained by the teacher. This is in line with DePorter & Hernacki (2008), who state that individuals with an auditory learning style prefer learning through listening and tend to remember information discussed rather than seen. This supports the theories of Polya (1973) and Munandar (2009), which emphasize the importance of generating multiple solution strategies and thinking flexibly in solving mathematical problems. The subject MD demonstrated the ability to re-examine problem-solving processes carefully and systematically. MD was also able to identify and correct a computational error in the second approach, indicating strong logical-mathematical intelligence, such as deep analytical thinking and an understanding of the relationships among mathematical concepts, as described by Gardner (1983). MD demonstrated aspects of creative thinking namely, fluency, through the ability to summarize and compare final results from two different approaches, and flexibility, by re-evaluating formulas and solution steps to ensure the accuracy of the answer, as highlighted by (Mairing, 2018; Anderson, 2009).

Subject FD demonstrated the ability to understand the problem systematically by clearly identifying the known and the unknown information, reflecting logical-mathematical intelligence as described by Fadila and Maknunah (2019). FD met aspects of creative thinking, namely *fluency*, by correctly and fluently articulating the known and unknown information, and *flexibility*, through the ability to provide various interpretations and understand the problem from multiple perspectives, as described by Ekayana et al., (2020) and Munandar (2009). This novel approach aligns with Sternberg & Lubert's (1995) theory of creativity and the characteristics of kinesthetic learning styles described by DePorter & Hernacki (2008).

Interview results show that FD fulfills all three aspects of creative thinking: fluency, flexibility, and novelty, by being able to clearly articulate problem-solving steps, offer various strategies, and create new methods for solving problems, in line with the views of Leksmono (2019) and Asmidi (2021). FD demonstrated logical-mathematical intelligence in executing problem-solving plans, using multiple strategies, including two previously taught methods and one novel approach. FD explained the solution steps clearly, incorporating kinesthetic learning through body movements. FD was able to adapt approaches to problem-solving and even created a new, previously unlearned method such as assigning specific values to *x* in the composition function**.**

FD reviewed the solution to the function composition problem using three different methods to ensure consistency of the result, which was 963 cakes. FD carefully verified each step, including checking the function f(x), its composition with g(x), and substituting values for x to ensure the correctness of the result. This reflects FD's logical-mathematical intelligence and kinesthetic learning style, which emphasizes hands-on experience in validating answers. FD demonstrated fluency by drawing consistent conclusions, flexibility by re-examining formulas to ensure correctness, and novelty by evaluating solutions that differed from others. These findings are in line with the theories of Mairing (2018), Anderson (2009), and Silver (1997).

Conclusion and Suggestion

The findings of this study have important implications, particularly in providing teachers with insights into how students with logical-mathematical intelligence demonstrate creative thinking based on their learning styles namely, visual, auditory, and kinesthetic. These insights can serve as valuable considerations for teachers to pay closer attention to students' problem-solving steps by taking into account their diverse learning styles. By doing so, teachers can better support the development of students' creative thinking abilities.

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