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Mathematical Creative Thinking Ability of Vocational School Students in Solving Composition Function Problems

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Abstrak

Kemampuan berpikir kreatif matematis sangat penting bagi siswa sekolah kejuruan, baik dalam memecahkan masalah matematika maupun dalam karir profesionalnya di masa depan. Namun fakta menunjukkan bahwa keterampilan ini tidak cukup ditekankan. Penelitian ini bertujuan mengkaji secara komprehensif kemampuan berpikir kreatif matematis pada berbagai level kemampuan matematika: rendah, sedang, dan tinggi. Penelitian menggunakan pendekatan deskriptif kualitatif, melibatkan 73 siswa kelas sebelas, sekolah kejuruan di Kota Langsa. Instrumen penelitian berupa tes, terdiri dari lima soal yang dirancang untuk menilai kemampuan berpikir kreatif terkait fungsi komposisi, serta wawancara untuk tambahan wawasan kualitatif. Analisis data dilakukan melalui reduksi data, penyajian data, dan verifikasi. Hasil analisis menunjukkan bahwa kemampuan berpikir kreatif siswa dalam konteks fungsi komposisi sebagian besar berada pada kategori rendah, sedangkan kemampuan sedang dan tinggi kurang dominan. Terdapat kebutuhan mendesak untuk menumbuhkan praktik berpikir kreatif untuk memastikan bahwa lulusan sekolah kejuruan dibekali dengan baik untuk menjadi pekerja produktif di berbagai sektor.
Kata Kunci: Fungsi Komposisi; Kemampuan Berpikir Kreatif Matematis; Level Kemampuan Matematis.

Abstract

The ability to engage in mathematical creative thinking is essential for vocational school students, both in solving mathematical problems and in their future professional careers. However, current observations indicate that this skill is not sufficiently emphasized. This study aims to comprehensively examine mathematical creative thinking abilities across different levels of mathematical proficiency: low, medium, and high. Employing a qualitative descriptive approach, the study involved 73 eleventh-grade students from a vocational school in Langsa City. The research instruments included a test consisting of five questions designed to assess creative thinking abilities related to composition functions, as well as interviews for additional qualitative insights. Data analysis was conducted through data reduction, data presentation, and verification. The analysis results indicate that students' creative thinking abilities in the context of composition functions are predominantly in the low category, with medium and high abilities being less prevalent. There is a pressing need to foster creative thinking practices to ensure that vocational school graduates are well-equipped to become productive workers across various sectors.
Keywords: Mathematical Creative Thinking; Composition Functions; Levels of Mathematical Proficiency.

I. INTRODUCTION

Vocational schools, as a key level of vocational education, aim to produce skilled workers equipped with the competencies needed in the business and industrial sectors. These graduates should be capable of developing their potential and adapting to advancements in science, technology, and the arts, as outlined in the independent curriculum (Restiana et al., 2019; Mujab et al., 2022). Consistent with this objective, the Ministry of Education and Culture asserts that graduates from SMA/SMK should possess competencies in creative, productive, critical, independent, collaborative, and communicative thinking (Kemdikbud, 2014; Dalilan & Sofyan, 2022). Therefore, embedding creativity in every lesson is paramount (Marzuki et al., 2019; Marzuki, Negara, et al., 2022).

Creativity is the outcome of cognitive processes involved in understanding and solving problems (Tarlina & Afriansyah; 2016; Marzuki et al., 2021; Zaiyar & Rusmar, 2020; Zubaidah et al., 2023). According to Fitrina et al. (2016), creative thinking ability (CTA) is defined as the cognitive process used to generate new ideas and thoughts independently. CTA involves the student's capacity to provide unique and unconventional solutions (Purwasih, 2019). Specifically, mathematical CTA refers to the ability to solve mathematical problems using multiple solutions (Rahayu et al., 2018; Silviana & Mardiani, 2021).

Mathematical creative thinking abilities (MCTA) can be developed in various settings, including schools, through mathematics education (Faturohman & Afriansyah, 2020; Marzuki, 2021). Mathematics is a fundamental science, requiring a deep understanding of basic concepts, which is crucial for enhancing MCTA (Budi et al., 2020; Syahara & Astutik, 2021). Effendi (2017) emphasizes that mathematics education in vocational schools transcends merely learning numbers or figures. It serves as a tool, language, and science, vital for developing adaptive thinking skills.

Mathematical Creative Thinking Ability (MCTA) is a crucial skill for students, particularly within the context of mathematics education (Muhammad, Septian, & Sofa, 2018; Marzuki et al., 2021). This ability is essential for students to prepare themselves for the challenges of an increasingly advanced era, enabling them to articulate ideas and solve a variety of problems. According to Miatun & Nurafni (2019), MCTA can be measured through four components: fluency, flexibility, originality, and elaboration. Silver (1997) suggests that creative thinking abilities can be assessed through fluency, flexibility, and novelty. Meanwhile, Torrance (1974) identifies fluency, originality, and elaboration as the key components for measuring MCTA.

An eloquent thinker generates numerous ideas, concepts, and approaches to solve diverse problems (Sari, Sukestiyarno, & Walid, 2022). Flexibility refers to the ability to provide varied responses to a question using existing solutions and to develop new ideas and solutions (Faiziyah, Hanan, & Azizah, 2022). This requires individuals to understand concepts from different perspectives or redefine ideas, thereby finding new ways to think differently (Marzuki et al., 2020; Sari & Afriansyah, 2022).

MCTA does not emerge spontaneously but requires extensive training. Teachers can cultivate and enhance students' MCTA by offering open-ended practice questions related to real-life mathematical problems. However, current observations indicate that students' MCTA remains relatively low. According to Lestari et al. (2015), teachers rarely engage students with open-ended mathematical problem-solving questions. Teaching practices often focus on meeting the Minimum Completeness Criteria (KKM), which is influenced by students' MCTA in problem-solving. Additionally, many teachers rely on outdated teaching materials (Sopian & Afriansyah, 2017; Fikriyah, 2019), leading students to perceive mathematics as difficult, boring, and intimidating. Consequently, students become disengaged from studying mathematics.

Meika et al. (2021) also note that students learn mathematics based solely on teachers' instructions, with their understanding limited to memorizing concepts, formulas, and procedures without comprehending the underlying principles or reasons for using specific formulas (Marzuki et al., 2022).

One of the reasons that differentiates this research from other research in the vocational school sector is that there is not much research that examines creative thinking abilities by taking into account the various levels of student ability (high, medium, and low), and the material provided in the field of mathematics has nothing to do with the vocational field in question. they choose, this is what causes the MCTA abilities of vocational school students to be very low previous research by Lestari & Zanthy (2019) indicates that vocational school students' MCTA in spatial geometry is very low, with a reported percentage of 42.44%. Furthermore, vocational students often perceive that mathematics lessons are unrelated to their chosen vocational fields.

Based on the aforementioned points, this study aims to conduct an in-depth investigation into the MCTA of vocational school students, categorized by low, medium, and high levels of mathematical ability in problem-solving. The objective is to comprehensively explore creative mathematical thinking abilities within these varying levels of mathematical proficiency.

II. Method

This study employs a qualitative research design with descriptive methods. Descriptive qualitative research involves the use of qualitative data to provide a comprehensive overview of students' Mathematical Creative Thinking Ability (MCTA) in solving composition function problems in vocational schools.

The research was conducted with eleventh-grade students from a vocational school in Langsa City. The data collection instruments included a validated MCTA test consisting of five questions related to composition function material, and interviews. The study involved 73 participants, categorized by their mathematical abilities into low, medium, and high levels.

The test instrument was structured to assess various components of MCTA: the first question targeted fluency, the second addressed flexibility, the third and fourth focused on originality, and the fifth evaluated elaboration. The non-test instrument, namely interviews, was conducted in-depth until data saturation was achieved, involving nine participants divided into three ability groups (high, medium, and low).

Students were categorized into MCTA groups based on their average scores and standard deviations. Students in the low group scored below the mean minus the standard deviation, those in the medium group scored between the high and low groups, and those in the high group scored above or equal to the mean plus the standard deviation.

Data validity was ensured through triangulation, specifically technical triangulation, which involved comparing the results from the MCTA test with interview outcomes. Data analysis followed the stages of data reduction, data presentation, and verification (Miles & Huberman, 1994).

III. RESULT AND DISCUSSION

Based on the test result of MCTA, the data obtained was displayed as follows:

Table 1.
Students' MCTA Test Result

Total Student	Max Value	Min Value	Average
73	100	25	51,94

Based on the data obtained, it was found that out of the 73 students in the research sample, only 45 students met the criteria for Mathematical Creative Thinking Ability (MCTA). The remaining 28 students did not meet any of the MCTA components and were therefore excluded from this category. The researchers conducted an in-depth analysis and categorized the 45 students based on their performance in the MCTA components, as indicated by their responses. These students were then grouped into three levels: low, medium, and high. This grouping was determined by the student's overall scores, considering the average score and standard deviation. Refer to Table 2 for detailed information.

Table 2.
Results of MCTA Score Classification of Students

MCTA Group Level	MCTA Score (N)	Number of Students	%
High	N ≥ 75,01	7	15,56%
Medium	28,87 ≤ N < 75,01	29	64,44%
Low	Ni < 28,87	9	20%
Total		45	100%

Based on the information in Table 2, 7 students (15.56%) exhibit high MCTA, 29 students (64.44%) demonstrate medium MCTA, and 9 students (20%) show low MCTA. Following this classification, the researchers conducted in-depth interviews with students from each ability group until data saturation was reached, which occurred with the ninth participant. Detailed data from participants across the three MCTA groups are provided in the subsequent description.

A. Student with MCTA High Group

The first set of MCTA data for students in the high-ability group was obtained from their responses to MCTA test question number 1. The results are illustrated in Figure 1 below.

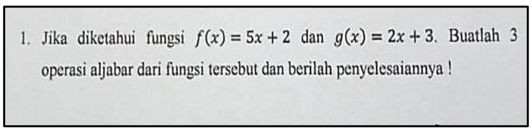
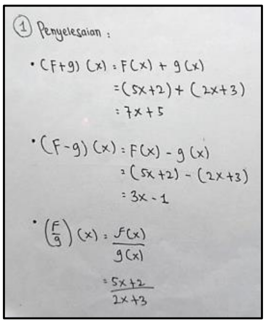

1. Jika diketahui fungsi $f(x) = 5x + 2$ dan $g(x) = 2x + 3$. Buatlah 3 operasi aljabar dari fungsi tersebut dan berilah penyelesaiannya !

Figure 1. MCTA Question No. 1

The question was then responded to with the following answer.


① Penyelesaian :

• $(f+g)(x) = f(x) + g(x)$
$= (5x+2) + (2x+3)$
$= 7x+5$

• $(f-g)(x) = f(x) - g(x)$
$= (5x+2) - (2x+3)$
$= 3x-1$

• $\left(\frac{f}{g}\right)(x) = \frac{f(x)}{g(x)}$
$= \frac{5x+2}{2x+3}$

Figure 2. TB 8 Response for Question No. 1

Figure 2 illustrates that the first question assesses the fluency component. Subject TB 8 scored 4 points because they provided relevant ideas, and their answers were correct, precise, and fluent.

The next MCTA question, number 2, is as follows.

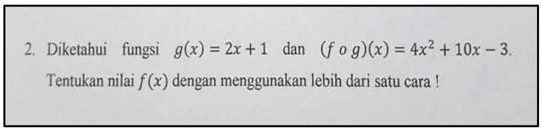
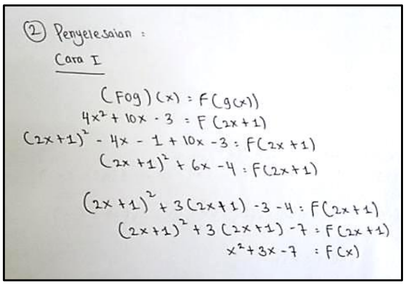
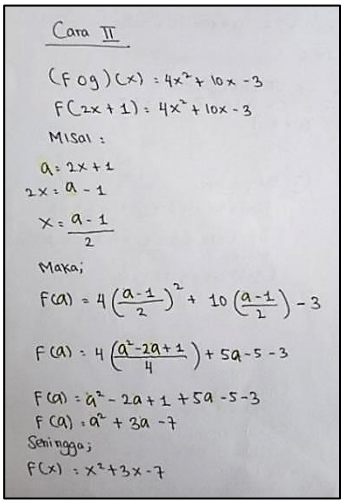

2. Diketahui fungsi $g(x) = 2x + 1$ dan $(f\ o\ g)(x) = 4x^2 + 10x - 3$. Tentukan nilai $f(x)$ dengan menggunakan lebih dari satu cara !

Figure 3. MCTA Question No. 2

The question was then responded by this following answer.


② Penyelesaian :
Cara I

$(f o g)(x) = f(g(x))$
$4x^2 + 10x - 3 = f(2x+1)$
$(2x+1)^2 - 4x - 1 + 10x - 3 = f(2x+1)$
$(2x+1)^2 + 6x - 4 = f(2x+1)$
$(2x+1)^2 + 3(2x+1) - 3 - 4 = f(2x+1)$
$(2x+1)^2 + 3(2x+1) - 7 = f(2x+1)$
$x^2 + 3x - 7 = f(x)$


Cara II

$(f o g)(x) = 4x^2 + 10x - 3$
$f(2x+1) = 4x^2 + 10x - 3$
Misal :
$a = 2x+1$
$2x = a - 1$
$x = \frac{a-1}{2}$
Maka;
$f(a) = 4\left(\frac{a-1}{2}\right)^2 + 10\left(\frac{a-1}{2}\right) - 3$
$f(a) = 4\left(\frac{a^2-2a+1}{4}\right) + 5a - 5 - 3$
$f(a) = a^2 - 2a + 1 + 5a - 5 - 3$
$f(a) = a^2 + 3a - 7$
Sehingga;
$f(x) = x^2 + 3x - 7$

Figure 4. Subject TB 8 Response for Question No. 2

The second question assessed the flexibility component of MCTA. Subject TB 8 scored 4 points, demonstrating the ability to solve the problem using more than one correct method.

The MCTA questions numbered 3 and 4 are as follows.

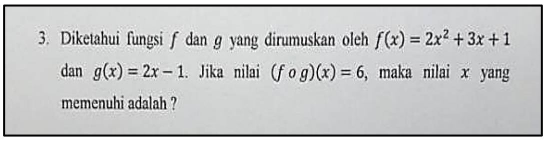

3. Diketahui fungsi f dan g yang dirumuskan oleh $f(x) = 2x^2 + 3x + 1$ dan $g(x) = 2x - 1$. Jika nilai $(f\ o\ g)(x) = 6$, maka nilai x yang memenuhi adalah ?

Figure 5. MCTA Question No. 3

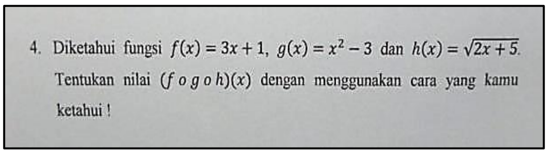

4. Diketahui fungsi $f(x) = 3x + 1$, $g(x) = x^2 - 3$ dan $h(x) = \sqrt{2x+5}$. Tentukan nilai $(f\ o\ g\ o\ h)(x)$ dengan menggunakan cara yang kamu ketahui !

Figure 6. MCTA Question No. 4

The followings are the subject's responses.

https://doi.org/10.31980/mosharafa.v12i4.1193

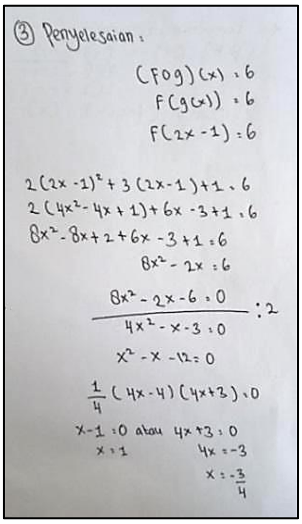


Figure 7. Subject TB 8 Responses for Question No. 3

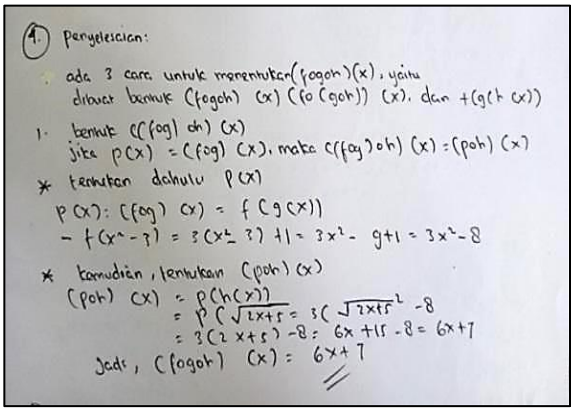
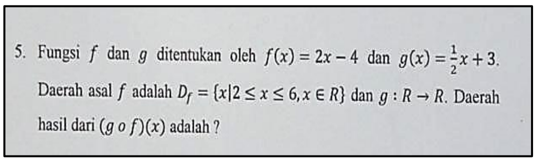


Figure 8. Subject TB 8 Responses for Question No. 4

The third and fourth questions both assessed the originality component. In question number 3, subject TB 8 did not demonstrate originality; however, in question number 4, subject TB 8 met the originality criteria. The score obtained by subject TB 8 for question number 4 was 4, as they were able to develop unique solutions and provide correct answers.

The final MCTA question, number 5, is as follows.



5. Fungsi f dan g ditentukan oleh $f(x) = 2x - 4$ dan $g(x) = \frac{1}{2}x + 3$. Daerah asal f adalah $D_f = \{x | 2 \leq x \leq 6, x \in R\}$ dan $g : R \rightarrow R$. Daerah hasil dari $(g \circ f)(x)$ adalah ?

Figure 9. MCTA Questions for Question No. 5

The response provided by Subject TB 8 was described as follows.

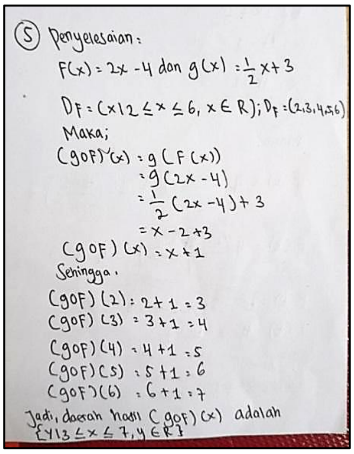


Figure 10. Subject TB 8 Response for Question No. 5

The fifth question assessed the elaboration component. Subject TB 8 scored 4 points, as they provided correct and detailed answers.

B. Student with MCTA Medium

Students with MCTA Medium Group were also given similar five questions as those with high MCTA student group. The subject responses were displayed as follows.

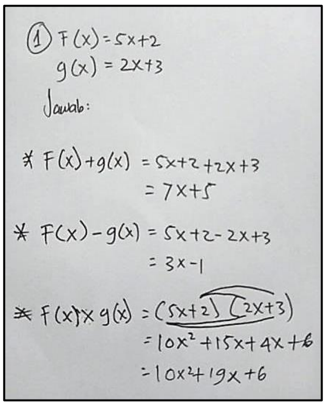


Figure 11. Subject BS 41 Response for Question No. 1

The first question encompasses the fluency component. Subject BS 41 attained a score of 4 as they were capable of providing a relevant idea regarding the problem-solving process, along with

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presenting an accurate, precise, and fluent response.

Furthermore, concerning question number 4, the response provided by subject BS 41 is as follows:

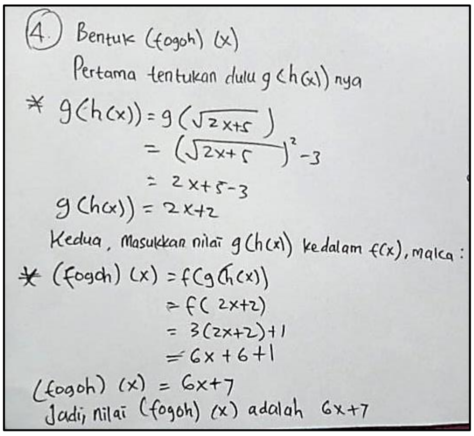

Figure 12. Subject BS 41 Response for Question No. 4

The fourth question involves the originality component. Subject BS 41 obtained a score of 4 due to the development of a unique response, devised in their own manner, which also proved to be correct.

As for the response to question number 5, it is presented below:

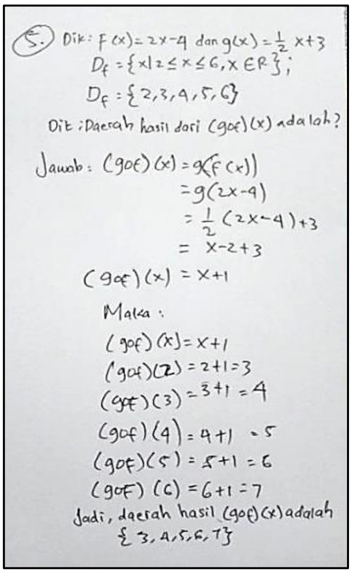

Figure 13. Subject BS 41 Response for Question No. 5

The fifth question encompasses a component of elaboration. Subject BS 41 achieved a score of 4, indicating proficiency in offering accurate and detailed responses.

Subject BS 41 encountered difficulty in solving question number 3 and failed to fulfill the flexibility component in question number 2. This challenge stemmed from their struggle in comprehending the problem statements and their limited experience in providing diverse solutions to a single question.

C. Student with Low MCTA Group

The low proficiency group was administered identical sets of five questions as those given to the high proficiency group. The responses from the subjects are presented as follows:

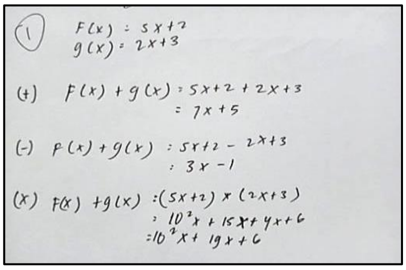

Figure 14. Subject TK 56 Response for Question No. 1

The first question entailed a fluency component. Subject TK 56 achieved a score of 4, demonstrating the capability to furnish responses featuring relevant ideas pertinent to the problem, alongside accuracy, precision, and fluency in articulation.

Out of the total 45 students, 9 belonged to the low proficiency group, all of whom solely managed to satisfy the fluency component in question number 1. These students exhibited limitations in offering diverse solutions, generating unique or elaborated responses rooted in personal methodologies, and elucidating the underlying problem-solving processes. This limitation is attributed to the students' inadequate practice in mathematical problem-solving, resulting in their inability to grasp the problem's essence and formulate effective problem-solving strategies.

An examination of the written test responses from participants categorized into high, medium, and low levels of Mathematical Critical Thinking Abilities (MCTA) on composition function material in vocational schools revealed notable differences in thinking processes. Students categorized under the high MCTA level exhibited proficiency across four thinking components, namely fluency, flexibility, originality, and detail. Moderate MCTA level students displayed competence in fluency and detail, while those categorized under low MCTA level demonstrated proficiency solely in fluency. These findings align with prior research by Marzuki et al. (2021) and Marzuki, Negara, et al. (2022), which highlight a correlation between students' mathematical abilities and the complexity of their thinking processes during mathematical problem-solving tasks. This is in line with the research results Nufus et al., (2024) students who have low self-regulated learning also have low creative thinking abilities in the learning process. This research further recommends the importance of paying attention to students' thinking abilities in mathematics classes at different educational levels, posing mathematical problems that enhance mathematical creativity, and training teachers to provide teaching practices that foster mathematical creativity. Mathematics learning activities in class carried out by students should not only focus students on their creative thinking abilities, but creative dispositions also need to be the focus of these activities. Mathematical problems that teachers pass on to students should not only be created by students working with pencil and paper, but also make students carry out actions or behavior that can trigger the development of various levels of students' creative thinking abilities ranging from high, medium and low (Ibrahim et al., 2024; Kurniasih et al., 2022; Shaw et al., 2022).

IV. Conclusion

Based on the research findings and analysis, it can be concluded that the creative thinking abilities of Vocational High School (SMK) students in solving composition function problems are generally considered moderate or have not yet reached the desired level as expected by the government. Despite demonstrating proficiency in addressing the fluency and elaboration components, students still exhibit shortcomings in flexibility and originality components.

The examination results reveal that creative thinking abilities among low proficiency group students only account for 20% of the total 45 students, demonstrating proficiency in only one component, namely fluency. Conversely, students in the moderate proficiency group show improvement by fulfilling two components, namely fluency and elaboration, at a rate of 64.44%. On the other hand, although only comprising 15.56% of the total students, high proficiency group students exhibit proficiency in all four components, including fluency, flexibility, originality, and elaboration.

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Therefore, educators are encouraged to familiarize students with diverse mathematical problems that offer varied solution approaches. This aims to stimulate students to provide relevant ideas regarding the given problems, thereby enhancing flexibility and originality skills. Particularly for educators in vocational schools, integration of real-life-based mathematical problems into teaching is recommended. Moreover, students should be encouraged to practice solving different types of mathematical problems using various approaches, not solely relying on examples provided by teachers or solution steps outlined in textbooks.

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