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Analysis of Creative Thinking Ability in Solving Problems Based on Students' Learning Styles

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ABSTRACT

Mathematical creative thinking ability plays a crucial role in helping students solve everyday problems. This study aims to assess students' creative thinking abilities by categorizing them into auditory, visual, and kinesthetic learning styles based on four indicators of mathematical creative thinking abilities, namely fluency, flexibility, novelty, and elaboration. This research is a qualitative descriptive study. The data collection methods used in this study include tests to determine students' mathematical creative thinking abilities, interviews, and documentation. The research findings were analyzed and classified into categories representing visual, auditory, and kinesthetic learning styles, with one research subject selected from each category out of 31 students. The results of the research are students with a visual learning style could solve problems fluently and efficiently while drawing accurate conclusions. Additionally, visual learners could approach problems in multiple ways and solve them independently with innovative thinking. Students with an auditory learning style could interpret problems but required more communication skills to effectively convey their ideas, draw appropriate conclusions, or evaluate the problems encountered. Lastly, students with a kinesthetic learning style required additional assistance in solving problems and responding to the given indicators.

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A. INTRODUCTION

Education is an effort to prepare individuals in facing various challenges through guidance activities (Islam et al., 2015). One of the subjects that is useful in daily life is Mathematics. It plays a crucial role in the development of science, technology, and information (Medyasari et al., 2022). Mathematics is an efficient and essential tool for all sciences, as every field of knowledge incorporates mathematical elements (Grégoire, 2016). Nizam stated that several core competencies are emphasized in mathematics learning, including learning and innovation skills, digital literacy, and life and career skills (Rashid et al., 2019). The competencies of this century require individuals to be collaborative, think critically, think creatively, communicate effectively, and solve problems (Abdurrahman, 2019). One of the essential competencies in school mathematics is mathematical thinking ability (Sitorus & Doctoral, 2016).

The mathematical thinking abilities required by students include critical thinking, problem-solving, mathematical connections, mathematical reasoning, and creative thinking. These abilities need special attention in the learning process (Zaenuri & Medyasari, 2021). Assessing creativity can be viewed as an effort to recognize students' creative abilities, solutions, and forms of synthesis across various domains, as well as their individual characteristics, in order to understand their creative strengths and potential. Because of this, Mathematical Creative Thinking becomes an important competence for students in school (Chamberlin et al., 2019; Kim et al., 2019).

Creative thinking is always associated with mathematics as it is a way to solve problems. Creative thinking is highly important today as problems become increasingly complex in all aspects of modern life, and an individual’s creativity is closely related to daily life, potentially leading to new discoveries. In line with this, Dewi and Marsigit stated that Indonesia emphasizes creativity-based learning at a rate of 200% compared to intelligence-based learning (only 50%). This perspective highlights the significant and essential role of creative thinking ability for students, especially in mathematics learning (Dewi & Marsigit, 2018).

Based on an international study measuring students’ mathematical and scientific achievement, the Trends in Mathematics and Science Study (TIMSS) conducted by the International Association for the Evaluation of Educational Achievement (IEA), Indonesia ranked 40th out of 42 countries surveyed in science in 2011 (Palacios et al., 2019). The TIMSS 2015 results also placed Indonesia 45th out of 48 participants, with student scores falling below the international average of 500. Additionally, Indonesia’s participation in the Programme for International Student Assessment (PISA) in 2015 showed that the country ranked 62nd out of 70 nations, with an average score of 403. Based on the TIMSS and PISA results, it can be concluded that Indonesian students' higher-order thinking skills remained low (Hartinah et al., 2019).

Isaksen & Treffinger stated that creative thinking is the process of constructing ideas that emphasizes fluency, flexibility, novelty, and elaboration (Barata, 2018). Mathematical creative thinking ability is the capacity to create and discover new ideas that are different, original, and uncommon, with definite and accurate results. There are four creativity skills that can foster a creative attitude. These skills include fluency, flexibility, originality/novelty, and elaboration. Lin & Wu outline four aspects for assessing students’ creativity: fluency, flexibility, uniqueness, and elaboration. an individual is considered creative if they can identify the given problem, determine various approaches (fluency), and produce diverse and appropriate answers (flexibility). Students must also be able to elaborate on the results of their elaboration (Lin & Wu, 2016)

Every student has a personal uniqueness that is different from the others. Each student is different in the level of learning speed and learning style. This difference in ways of learning shows the easiest way for students to absorb information during learning. The easiest and fastest way for a person to learn is known as a learning style. The key to success in learning and working is knowing the unique learning or working style of each person, accepting one's strengths and weaknesses and adjusting personal preferences as much as possible in every situation of learning, study and work (Marzuki et al., 2019). Thus, style learning is the key to student success in learning. Students can generate high-quality creative works as a result of their thinking if they are consistently trained and guided to think creatively. The teacher’s role in fostering creative-thinking students is to train and stimulate each student to explore their creative talents, as every student has the potential to engage in creative activities.

Students are naturally driven by curiosity; at this stage, the teacher acts as a facilitator to nurture their curiosity. Educational practitioner Arif Rachman asserts that creativity develops through appropriate learning processes; therefore, teachers are required to guide students in alignment with their learning styles. One of the students' characteristics that affects their ability to think creatively is their learning style. Students' interest in learning is also a crucial factor in the attainment of instructional goals. When the learning style aligns with a student's personal characteristics, their motivation and engagement in learning tend to increase. Learning interest refers to a student's inclination to demonstrate attention and enthusiasm toward various aspects of the learning process (Aulia et al., 2024). It is related to how students comprehend lessons, particularly in mathematics. Each learner has a unique learning style (Sahatcija et al., 2017). Some students understand better through visual objects/images, some grasp concepts more easily by listening to teachers' explanations, and others learn best through physical activities in the classroom. DePorter and Hernacki classify learning styles into three types: visual, auditory, and kinesthetic (V-A-K). In this regard, teachers play a crucial role in understanding their students' learning styles, enabling them to guide students effectively to improve learning outcomes (Aulia et al., 2024).

There are three types of learning styles, namely visual, auditory and kinesthetic. Visual learning style: this type of learning style is learning by seeing, student who have this learning style are informed by having eye contact with what is learned. Auditor learning style: this type of learning style is learning by listening, does not require eye contact, but quite optimizes hearing only while Kinesthetic learning: learning style types are learning how to move, work and touching, so that he does not like to sit for long to listen to lectures only He tends to move, touch, and do. If a teacher can identify trends in student learning styles, this will be very useful in developing the teaching and learning process. Based on the explanation above, learning styles are the easiest and fastest way for a person to learn.

The study in this study is visual learning style, suditory learning style, and kinesthetic learning style. When students develop their creative abilities using the appropriate and suitable learning style, their academic performance becomes optimal. This finding is further supported by research conducted by Jehadus, which shows that a positive correlation coefficient indicates that creative learning and learning styles are positively correlated to students' mathematics achievement (Hariri & Wibawa, 2025). If students possess high creativity and understand the learning style that best suits their personality, their mathematics performance will also be high. Based on the explanation above, the objective of the present study was to analyze students' mathematical creative thinking abilities in relation to their learning styles. This research will contribute to the scientific literature in education, particularly regarding the relationship between learning styles and creative thinking skills. This will enable teachers to design more effective learning strategies.

B. METHODS

This study employed a descriptive qualitative research approach. It aimed to analyze students' creative thinking abilities in mathematics based on their learning styles. The sample for this study consisted of students from SMA Negeri 26 Batam, Riau Islands, selected using a purposive sampling technique, in which participants were deliberately chosen based on specific criteria relevant to the research. Three students were selected through this technique, each representing a different learning style. The data analysis technique employed in this study adopts the framework proposed by Miles and Huberman, consisting of three stages: data reduction, data display, and conclusion drawing (Sugiyono, 2011). The data obtained in this research comprised students' learning outcomes, collected using an assessment instrument in the form of an essay test designed to measure mathematical creative-thinking abilities. The test incorporated four indicators: fluency, flexibility, novelty, and elaboration. The qualitative data analysis procedures applied in this study were as follows: (1) Data reduction, which entailed summarizing, organizing, and focusing the data derived from the research findings, as well as eliminating irrelevant or unpatterned information to ensure alignment with the research objectives; (2) Data display, whereby the reduced data were presented in a concise and systematic descriptive format to facilitate comprehensive and detailed understanding; and (3) Conclusion drawing and verification, in which conclusions were formulated based on the analytical results of all collected data, followed by verification to ensure their validity. The subjects in this study were students with a visual learning style (S-01), students with an auditory learning style (S-02), and students with a kinesthetic learning style (S-03). The research instruments used in this study included tests, documentation, and interviews. To ensure the validity of the findings, triangulation was conducted by administering tests and conducting indepth interviews with the students. Their responses were analyzed by assessing the accuracy of their answers and evaluating indicators of creative thinking in problem-solving. The collected data were analyzed using a descriptive method, providing a detailed examination of students' creative thinking processes. Each indicator of creative thinking ability is presented in Table 1.

Table 1. Indicators of Creative Thinking Ability

No	Aspect and Indicators
1	Understand the problem Identify aspects that known on the problem
2	Fluency Respond the questions with many alternative questions coherently and thoroughly
3	Flexibility See a problem from different perspective thinking in
4	Originality Reveal new and unique ideas
5	Originality Reveal new and unique ideas

C. RESULT AND DISCUSSION

This study was conducted on 31 students. The subjects were first grouped based on their learning style before being analyzed the students' creative thinking ability. Based on the research findings, 9 students were classified as having a visual learning style, 8 students as having an auditory learning style, and 13 students as having a kinesthetic learning style. The student grouping data obtained based on the learning style category is shown in Figure 1.

Figure 1. Grouping of Students' Learning Style

From each learning style group, one student representing each category was selected for further analysis. This section presents an analysis of students' mathematical creative thinking abilities based on their respective learning styles. The results of the study were as follows.

1. **Creative Thinking Ability Of Student Subject S-01 With A Visual Learning Style**

Based on the test answers, it was found that Subject S-01 could correctly identify the given problem. The interview results with Subject S-01 confirmed that the student could identify the problem by stating both the known information and what was being asked in the question. The student could solve the problem using one method and then correctly provided an alternative method. There were no errors in the problem-solving process. Both approaches led to the same and correct result. Subject S-01 demonstrated a clear understanding of the problem, enabling them to solve it smoothly. The interview results revealed that Subject S-01 could explain the solution steps in a structured and coherent manner. The student could also interpret the symbols used in the solution. Additionally, Subject S-01 expressed confidence in the accuracy of their answer and demonstrated knowledge of alternative methods to solve the problem, as shown in Figure 2.

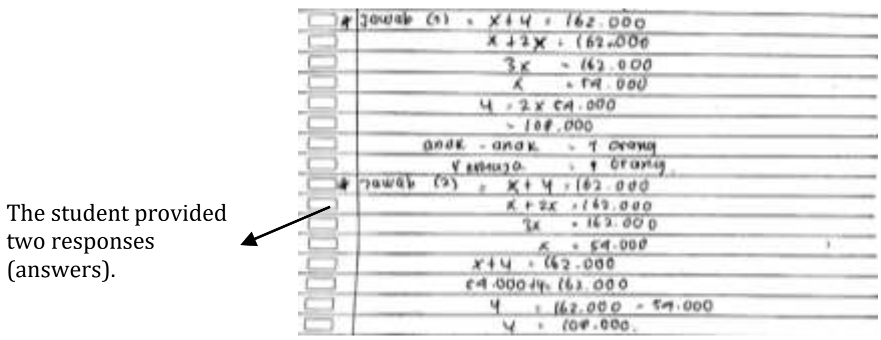

Figure 2. Written Test Results of Subject S-01

Based on the posttest and interview findings, Subject S-01 correctly answered. The fluency indicator question. During the interview, Subject S-01 explained their thought process in detail, providing logical and accurate reasoningas shown in Figure 3.

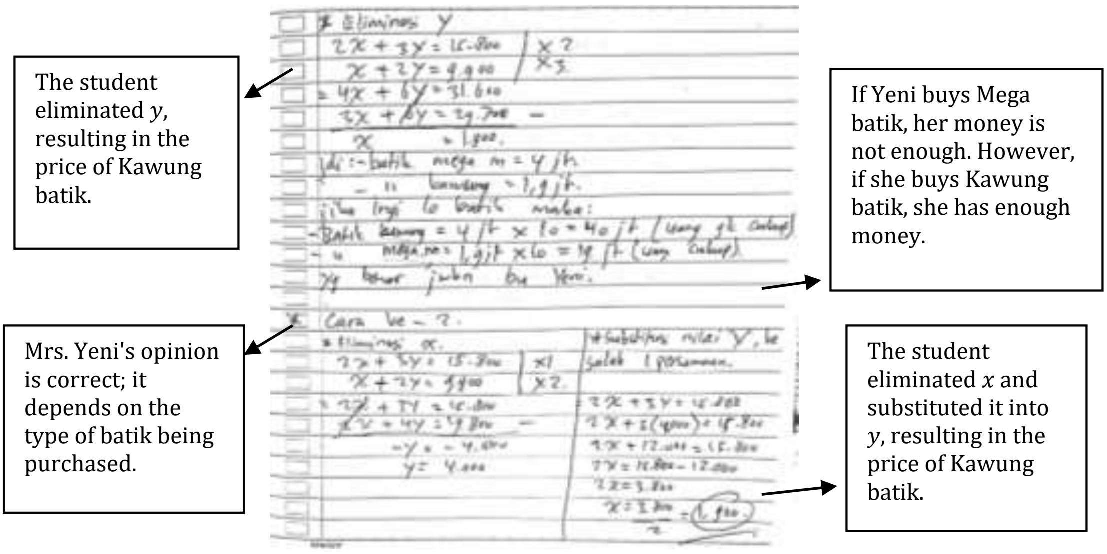

Figure 3. Written Test Results of Subject S-01

From the response to question number 1 (as shown in the figure), it was observed that Subject S-01 could provide more than one answer, all of which were correct, accurate, and complete. The problem-solving approach involved mathematical modelling. The interview results showed that Subject S-01 successfully solved the problem using two different methods: the elimination method and a combined approach using the equations. The student could also determine two valid answers by considering the number of batik pieces purchased in the problem scenario. Subject S-01 could solve question using appropriate steps. Interview results further confirmed that Subject S-01 solved question in a detailed manner, following appropriate steps and achieving accurate results. This demonstrates the student's ability to meet the elaboration aspect of creative thinking. Therefore, it can be concluded that S-01 successfully fulfilled the elaboration criterion.

2. Creative Thinking Ability of Student Subject S-02 with An Auditory Learning Style

Based on the test answers, it was found that S-02 could accurately identify the given problem, as shown in Figure 4.

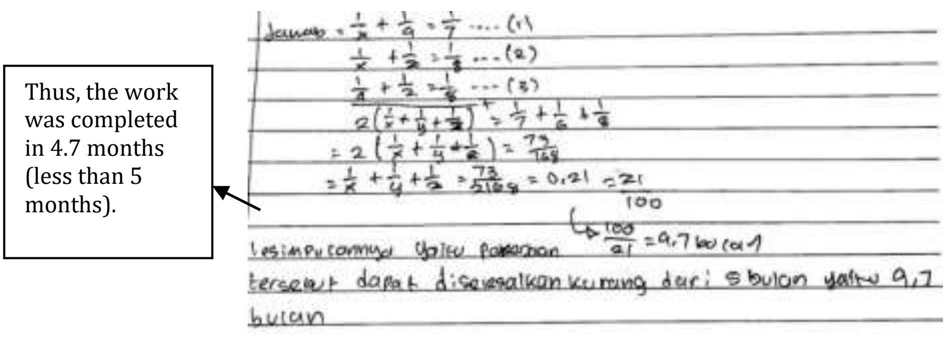

Figure 4. Written Test Results of Subject S-02

From the test results, it was evident that S-02 provided the correct answer. However, the steps and problem-solving process were not written in detail, even though thel final answer was correct. The researchers conducted an interview to further analyze the fluency indicator in S-02's mathematical creative thinking ability. The interview revealed that while S-02 encountered difficulties in solving the problem, they were confident that their answer was accurate Based on both the test answers and the interview, S-02 demonstrated fluency in problem solving by providing the correct response written response. Nonetheless, during the interview, S-02 could clearly explain their reasoning and how they arrived at their answer. This indicates that S-02 met the fluency indicator. S-02 could demonstrate only one method of solving the problem and could not provide alternative approaches. To further explore the flexibility indicator, the researchers conducted an interview. The interview revealed that S-02 struggled to come up with different solutions. Based on these findings, S-02 displayed limited flexibility in problem-solving and did not meet the flexibility indicator, as shown in Figure 5.

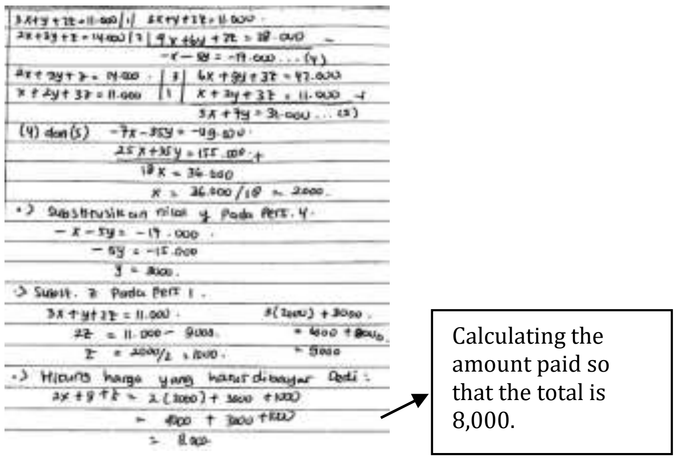

Figure 5. Written Test Results of Subject S-02

Subject S-02 successfully solved the problem in detail using appropriate steps. The test results showed that S-02 could determine the values of x, y, and z, as well as calculate the total cost as $2x + y + z$. The interview results further confirmed that S-02 could provide a detailed response with accurate steps, fulfilling the elaboration aspect. While they could find the correct solution, they struggled to determine alternative methods to solve the problem.

3. Creative Thinking Ability of Student Subject S-03 with A Kinesthetic Learning Style

Based on the test answers, it was found that S-03 could accurately identify the given problem, as shown in Figure 6.

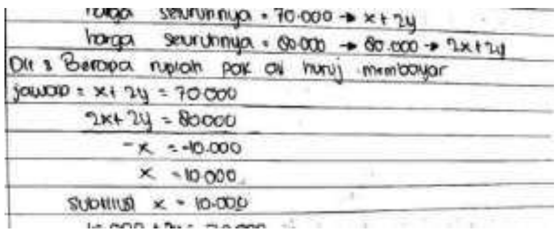

Figure 6. Written Test Results of Subject S-03

S-03 could solve the problem using a single method. However, there was a miscalculation during the problem solving process, as the student failed to determine the correct value of y, leading to an incorrect final answer. During the interview, S-03 could explain the steps involved but made calculation errors and expressed uncertainty about the answer. Based on the triangulation results, S-03 did not demonstrate fluency in problem solving. S-03 could not provide more than one solution to thel problem. The student only used the commonly applied elimination method to determine the required value as a result, the flexibility aspect was not fully met, as shown in Figure 7.

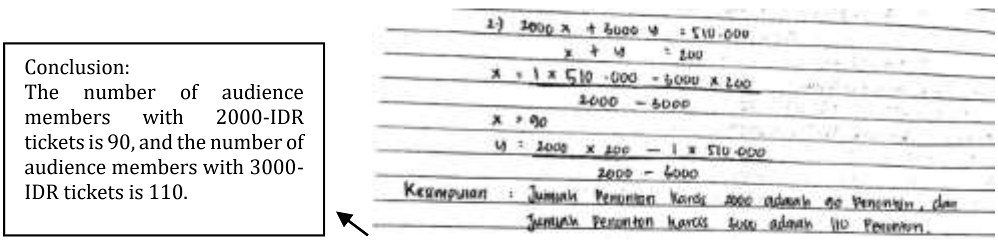

Figure 7. Written Test Results of Subject S-03

S-03 could solve the problem by following specific steps, but the steps were neither detailed nor sequential. However, the student could write the conclusion of their answer. Therefore, it can be concluded that S-03 did not fully develop the elaboration aspect of creative thinking. The following table illustrates the classification of creative thinking abilities in terms of students' learning styles, as shown in Table 2. The analysis of creative thinking ability of students based on visual learning, auditory learning, and kinesthetic learning based on creative thinking ability indicators: identification, fluency, flexibility, originality, and elaboration. Mathematical ability in students' learning processes is closely related to their learning preferences (Altun & Serin, 2019; Azzi et al., 2020; Fatahi et al., 2016; Rooney & Nyström, 2018). Learning styles are classified into various models, including the Big-5 model, Kolb's model, LS Honey and Mumford model, Dunn and Dunn learning style model (Visual-Auditory-Kinesthetic model), Felder-Silverman LS model, Carl and Myers-Briggs Type Indicator (MBTI) model, Gregorian model, Howard Gardner's Multiple Intelligences model, and Chris Jackson's Learning Styles Profiler (Jafari & Abdollahzade, 2019; Khenissi et al., 2016). DePorter & Wahab (2020) classify learning styles into three main types: visual, auditory, and kinesthetic (V-A-K). The ability to interpret problems is considered a fundamental factor and the first step in the creative process. Interpreting information must be accompanied by an understanding of the mathematical context of the problem.

Table 2. Creative Thinking Ability of Research Subjects

Aspects	Learning Style		
	S-01 (V)	S-02 (A)	S-03 (K)
Identification	√	√	√
Fluency	√	√	×
Flexibility	√	×	×
Originality	√	×	×
Elaboration	√	√	×

The better the understanding of mathematical content, the more accurate the solutions to the problem (Kolar & Hodnik, 2021; Nurwahyu et al., 2020). This aligns with findings from subjects with visual and auditory learning styles, who could comprehend the context effectively, perform calculations accurately, and meet the indicators of fluency, flexibility, and elaboration in creative thinking abilities. This finding is consistent with (Reder et al., 2020), who argues that mathematical understanding is a predictor of numeracy skills. The student with visual learning demonstrated the ability to introduce a "new" approach that had not been previously encountered in class. The student provided correct answers, clearly outlined the given and required information in the problem, and formulated a mathematical model with precision, fulfilling the identification indicator. Furthermore, S-01 could find an alternative solution that aligned with previously learned concepts, accurately solving the problem using a different method-meeting the problem-solving flexibility indicator. The students with a visual learning style can provide varied answers. The student also demonstrated the ability to expand upon learned concepts, provide accurate answers, and explore the problem in greater depth. This aligns with the originality indicator, which assesses the ability to generate original ideas while adhering to learned concepts.

Additionally, the student's creative thinking response sheet was found to be neat and well-organized, reflecting the characteristics of a visual learner. The test and interview results indicated that students with a visual learning style could successfully meet all indicators of creative thinking ability. Their problem-solving process was structured and coherent. Moreover, the subject demonstrated meticulous attention to detail when solving the given problems, resulting in optimal performance. Among the visual learners' group, students excelled in the five creative thinking indicators: identification, fluency, flexibility, originality, and elaboration. In the flexibility indicator, namely skill in searching for varied alternative answers, subject S-01 is able to provide varied answers.

One crucial factor influencing mathematics achievement is the student's learning style. Learning styles are potent indicators of students' personal preferences for treatment and learning information and their communication with learning materials, environs, and other students (Burcu, 2024). Because learning styles can assist students and coaches become more aware of their powers and weaknesses, they are very relevant in education. Romanelli et al. (2009) also revealed that many people believe that learning style is an aspect of the success of higher education. The results of which show that students with a visual learning style can provide varied answers. The authenticity indicator is the student's skill in providing unique ideas. This is in line with research conducted by Raiyn (2016), the results of which show that students with a visual learning style can provide unique ideas. The detail indicator is that students are able to develop an idea that they receive.

This is in line with research conducted by Irbah et al. (2018), research results show that students with a visual learning style are able to develop their own thinking. Failure to interpret information could lead to errors in subsequent creative thinking indicators. Subjects in the visual and auditory categories did not experience difficulties in interpreting information as a whole. Meanwhile, subjects in the kinesthetic category struggled with comprehensively interpreting information. The ability to understand text impacts comprehension issues (Gal et al., 2020). The representations used by students are influenced by their understanding of the information.

D. CONCLUSION AND SUGGESTIONS

Based on the results and discussion, it can be concluded that students with a visual learning style could identify given problems, employ different approaches to solve them, and effectively elaborate on details. Students with a visual learning style outperform those with an auditory learning style. Auditory students are able to meet the indicators for creative thinking skills in mathematics with assistance (stimulus). in contrast, students with a kinesthetic learning style demonstrated lower creative thinking abilities and had not optimally achieved all four aspects of creative thinking. As a recommendation, this study suggests the development of a learning model that teachers can use as an alternative in mathematics instruction to enhance students' higher-order thinking skills, particularly their creative thinking abilities.

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