Analysis of Students' Mathematical Creative Thinking Process Based on Cognitive Style

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An in-depth examination of the topic using the reflective cognitive style can answer questions regarding one's capacity for creative thought. It is accomplished through preparation, intuition, incubation, and verification. The stages of incubation and illumination are carried out once the verification stage has been completed. During the verification phase, they are coding on the shape of the flat side. Process of reflective student intuition according to characteristics of students who apply the appropriate completion strategy. Students who act without thinking first have yet to answer questions requiring creative thinking successfully. It can be seen from the preparation process, which needs to be more thorough to produce correct answers.

Keywords: mathematical creative thinking process, cognitive style

INTRODUCTION

The educational paradigms of the twenty-first century are geared toward cultivating human resources (Zubaidah et al., 2018). Mathematics is a field of study that finds use in many different aspects of life (Kenedi et al., 2019). Education in this century is expected to be able to use creative thinking abilities (Maskur et al., 2020; Sternberg, 2012; Tindowen et al., 2017). The thinking process entails the brain's active manipulation of information to deduce conclusions and resolve issues (Letseka, M & Zireva, D. 2013.). Therefore, one can conclude that creative thinking is essential (Nuha et al., 2018).

In fact, in the field, teachers still need to pay more attention to students' creative thinking abilities while in school. Instead, children are encouraged to work on problems by the stages carried out by the teacher, which prevents students from developing their creative abilities in mathematics. The school where the research was conducted also had students with common mathematical knowledge—the problem throughout the school can find. Based on the results of a survey of interviews with subject teachers when they were working on math problems, students were low on flexibility. According to the responses given by the students, there is a tiny variation and almost no difference. At the elaboration stage, the students have not been able to develop the results of their thinking in sufficient detail, which means that satisfactory conclusions have not been reached.

The ability to think creatively requires a process that can lead to creativity, but teachers should pay more attention to the stages of the thinking process to get an answer. Students can communicate their thoughts and come up with something original when they engage in creative thinking because this allows them to do so. Something new in this context not only results in the creation of something new, but it also has the potential to be the product of the fusion of two or more previously established ideas (Rahmah, 2012).

According to Botella et al. (2018), the importance of creative thinking processes in art classes can help educators develop students in the arts. Beliefs, in addition to students' cognitive abilities, can play a role in determining the extent to which they succeed in achieving their academic potential and maximum scores. Confidence that arises can increase motivation (Roland, B & Jean, T, 2012). Finding student answers varies according to the different characteristics of students (Singer et al., 2017). Various elements can be seen in cognitive style with a person's way of processing information (Euenjoo & Doohun, 2005). There is a relationship between cognitive style and creative thinking skills (Corgnet et al., 2016; Silva, 2015; Emir, 2013).

The contribution of this research is that solving mathematical problems related to the ability to think mathematically creatively will be closely associated with the characteristics of students with a reflective and impulsive cognitive style. In other words, the ability to think mathematically creatively will be closely related to the ability to solve mathematical problems. As a result, this study's objective was to investigate students' mathematical creative thinking processes when resolving issues on flat-sided shapes. More specifically, the investigation sought to examine these mathematical creative thinking processes in terms of reflective and impulsive cognitive styles.

The creative process involves various mental activities (Kaufman et al., 2008). Creativity means creating unique ideas by drawing on existing knowledge (Runco & Jaeger, 2012). High creativity can provide new problem-solving concepts (Argarini et al., 2014). Creativity is creating new ideas and original actions (Leikin, 2013). The concept of creativity, according to (J. Sitorus & Masrayati, 2016), is related to the theory of the hemispheres of the human brain. According to the idea of the hemispheres, the human brain is divided into two parts, referred to as the left and right hemispheres, and each of these parts is responsible for a specific function. The highest level in cognitive processes is the ability to think creatively (Mohanty, 2015; Wahyudi et al., 2020). The components of the ability to think creatively include fluency and flexibility.

The thought processes of some individuals consist of more stages than those of others. Initiation, Keeping, Shining Light, and Checking for Accuracy (Wallas, G, 1926; Sadler-Smith, 2015; Kanematsu & Berry, 2016). According to Piirto (2014), there are seven characteristics in the creative thinking process which consist Inspiration, Insight, Intuition, Incubation, Improvisation, Imagery, and Imagination. Intuition is needed as a stage of the creative thinking process. According to Gilhooly (2016), intuition is the power of the mind to feel the truth without reason or analysis immediately. The convergent thinking process plays a role in making decisions based on existing ideas, while divergent is produces many ideas that use intuition to solve problems (Ridong & Xiaohui, 2017). The complexity of ideas that students must possess and the existence of creative thinking in making and finding new strategies for solving problems (Arieti, S, 2011; Mumford, MD et al., 2012). The indicators that are taken into consideration are preparation, intuition, incubation, illumination, and verification. These stages are taken from the mathematical creative thinking process.

In preparation, one investigates a problem, places themselves in a position of analysis, and enters the stage of being conscious but not receiving a solution (Klein, 2013). Gilhooly (2016) The power of the mind to immediately feel the truth without using reason or analysis is what we mean when we talk about intuition. The fact is regarded presently in the form of knowledge founded on belief. According to Stierand and

Dorfler (2016), the origin of every innovative idea can be traced back to an intuitive flash of insight. The incubation process is an essential part of creative thinking that is often overlooked (Ritter, SM, & Dijksterhuis, A, 2014). The method of incubation is beneficial to creative thinking (Sio & Ormerod, 2009). Illumination analyzes parts of mathematical ideas and synthesizes them, finds creative ideas, connects ideas, and solves contextual problems. There is a process of spontaneous action in interaction and communication (Gordon Calvert, LM, 2001). The method of verifying new ideas that have been documented is called validation (Hines et al., 2019).

The cognitive style links an individual's intelligence and personality (Sternberg & Elena, 1997). Individual characteristics include responding, processing, storing, thinking, and using the information to respond to a task or various environmental situations (Kozhevnikov, 2007). Describe how to remember some information (I. Cintamulya, 2019). Several cognitive styles have been put forward by psychologists, including the reflective cognitive style and the impulsive cognitive style. The characteristic of the nostalgic cognitive style is using a long time to answer a problem (Rozencwajg et al., 2005). On the other hand, children whose cognitive style is impulsive tend to respond to questions with hasty but incorrect answers. The following table illustrates the differences between reflective and impulsive mental types by comparing their respective characteristics:

TABLE 1
CHARACTERISTICS OF REFLECTIVE AND IMPULSIVE COGNITIVE STYLES

Reflective	Impulsive
Providing an answer to an old question	willing to speak up without first being questioned
Similar to those of the analog variety of questions	Do not like the type of analog questions
Using strategies in solving problems	Do not use the technique in solving problems
Reflective of high literature	Often answered incorrectly
More accurate answer	Inaccurate answer
Reflective	Impulsive

RESEARCH METHOD

This study is a qualitative descriptive study that examines the processes and outcomes of creative thinking in students; with the help of the Matching Familiar Figures Test ($MFFT$), the research subjects comprised two students who exhibited reflective cognitive styles and two who showed impulsive cognitive techniques. The instrument has been tested for validity and reliability based on the views of experts in their field. Conduct this research in one of the junior high schools in the Ciamis district for one month. The researcher is the primary instrument, and the $MFFT$ test and a test of creative thinking skills on flat-sided shapes are the supporting instruments. The primary device is the researcher himself. Data are collected through evaluation tests, observations, and in-depth interviews (Sukestiyarno, 2020). In-depth interviews using a voice recorder so that the expected results are achieved. Data reduction, data presentation, and conclusion are the components that make up data analysis. Data reduction happens during coding to make the analysis process more straightforward. The next step is verifying the information and then concluding it.

The MFFT test gives to 30 class VII students, and then the researcher analyzed how much time it took to work on the questions and the scores each student got. The $MFFT$ test is a test to assess reflective and impulsive cognitive styles developed by Warli (2009) and adopted by Jerome Kagan. This test is designed to measure mental speed in a technical sense. There are four distinct types of categories for subjects, and they are as follows: reflective, impulsive, fast accurate/accurate, and slow inaccurately. The examination is comprised of thirteen questions that are ordered according to standard images (standard) and variation images (stimulus). The results for the reflective cognitive style $t \leq 7.38$ minutes with $f < 7$. The subject's impulsive cognitive style in solving questions $t \leq 7.38$ minutes and $f \geq 7$.

According to the test results, nine individuals have a reflective style, and seven have an impulsive style. After conducting additional analysis on the research subjects obtained through the $MFFT$ test, students who tended to use thoughtful and whimsical cognitive strategies were selected for the study. Based on the results of this second round of analysis, one participant was chosen to have a nostalgic cognitive style, and the other was determined to have an impulsive cognitive style. The selected subjects were tested on their ability to think creatively and mathematically. Subjects with a reflective cognitive style were assigned R1 coding, while subjects with an impulsive cognitive style were assigned IM coding.

RESULT AND DISCUSSION

The MFFT result on reflective subjects is R1, and the matter is analyzed for creative thinking processes based on preparation, incubation, illumination, and verification stages.

The first step, preparation, is taken in R1's first topic. Determine the nature of the issue in its entirety. After you have determined what is being asked in the problem, you should write down the length of the 3 cm rib, count the number of cubes in the problem, and then determine what is being asked in the issue. During the second stage, subject R1 provided an open and honest response concerning the intuitive process that will use to implement the strategy. Subjects can directly identify themselves by specifying keywords. The participant opened the answer sheet a few moments later and wrote down the concept used, explicitly using the geometric image. In the incubation stage, students remain silent and take a short break to enter the subconscious before entering the following problem. The next step is finding ideas at the scene of the illumination process.

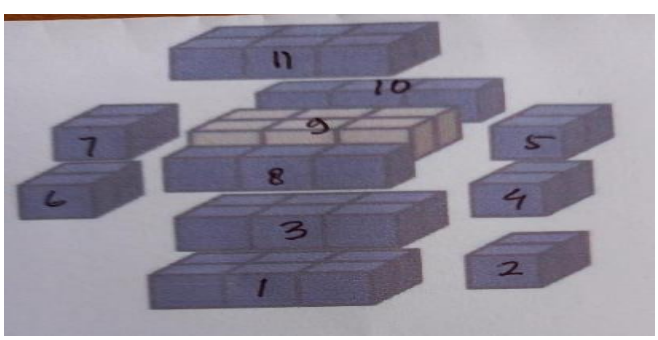
It does this by bolstering the findings of the researcher's analysis regarding the steps involved in the creative thinking process, which are based on the results of interviews with the subject:

Researcher:	"Why use the cube concept?"
R1:	"Because if the space builds are combined, they will form a cube"

According to the subject's response, the creative thinking process is underpinned by intuition; there is a direct and spontaneous answer, and the truth does not require analysis.

During the verification phase of the process, the subject assigns a number to the question, which can be seen in the figure that follows:

FIGURE 1
THE PROCESS OF IDENTIFYING THE ANSWERS TO THE GEOMETRIC NUMBERING BY SUBJECT R1



In the first method, the individual begins calculating the volume by providing the numbering based on Figure 1. The counting procedure starts with the shape numbered 1, a form composed of six cubes of the same size. The following calculations are performed by R1 utilizing the cube volume concept:

FIGURE 2
CALCULATION OF WAKE USING METHOD ONE BY SUBJECT R1

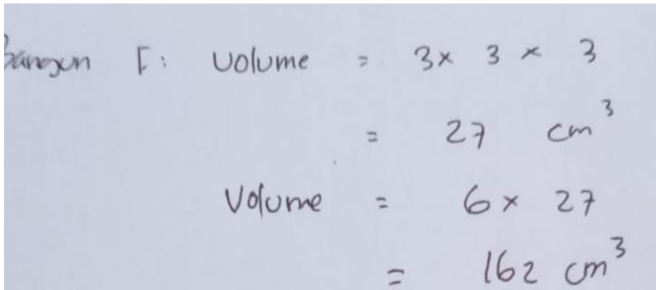
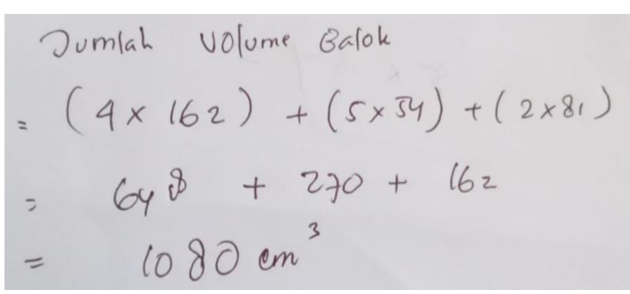


Figure 2 depicts a calculation made by Subject R1 to determine a cube's volume, which can find using the formula S x S x S and is equal to 27cm^3. The subject multiplies the number of cubes in shape one by the volume of the cube to arrive at a total of 162cm^3; this is because the number of cubes in shape 1 is 6. Because figures 3, 9, and 11 all have the same general shape as figure 1, participant R1 calculated the volume of the cubes in each figure. In figures 2, 4, 5, 6, and 7, which each consist of two cubes, the participants followed the same procedure to obtain a volume of $54\ \text{cm}^3$, and they followed the same technique to get a book of $81\text{cm}\ ^3$ in figures 8 and 10, which each consist of three cubes. The findings of the interview are as follows, based on the approach that took to working on the subject:

Researcher: "So that you get results like that, try to explain how it works".
R1: "Based on my intuition and experience, the first step is to make it easier for me to divide first based on the number of blocks there are 2, 3, and 6. Then I first calculate the volume using the volume formula of the blocks. For building numbers 1,3, 9, and 11, the importance of the partnerships is $27\text{cm}\ ^3$ because there are 6 pieces. I multiply $27cm^3 \text{ x } 6$ to become 162cm^3. Buildings 2, 4, 5, 6, and 7 have $54\ cm^3$, and Buildings 8 and 10 have a volume of $81cm^3$"

The first step in the verification process involves adding up the volume of each numbered shape, beginning with build 1 and going up to build 11. The topic examines each number once more and then adds the totals so that the following figure can obtain the answer.

FIGURE 3
RESULTS OF THE FINAL VERIFICATION OF SUBJECT R1 IN METHOD 1

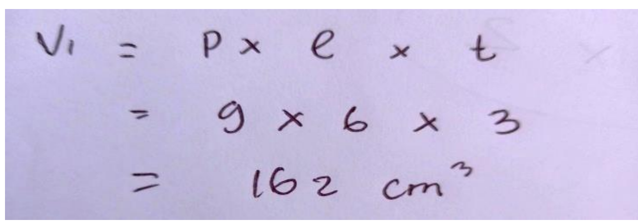


In the second method, the individual who has had their intuition awakened in a previous step sketches a rectangular image. After that, the subject maintained silence while going through the incubation procedure. He kept quiet for a short period by paying attention to the pictures of the questions and making additional scribbles. As a result, the subject used a unique approach by using the block concept. At the initial verification stage, it can be identified by looking at the subject's streaks in the form of blocks. Interviews were carried out with the following findings to provide evidence that this approach is authoritative:

Researcher:	"What other methods are there for calculating the volume of the cube?"
R1:	"The block concept is going to be utilized by me". (reply assuredly without conducting any preliminary research)
Researcher:	"Are you sure about what you're doing?"
R1:	"I'm sure, madam. Based on the vision, it looks like a block"

The response provided by the subject demonstrates that the issue makes use of intuition that is based on sight. After that, the matter successfully convinced the incubation process of the work results up until the verification step. The same topic is referred to in the numbered descriptions of the shape. The subject then performs the calculations to determine that the length of the beam in shape 1 is, the width is, and the height is. For the outcomes of the mathematical analysis of the topic to be obtained, the subject calculated that the beam length in figure 1 is $3cm + 3cm + 3cm = 9cm$. The width is $3cm + 3cm = 6cm$ and the height is $3cm$. So the results of the subject calculation obtained by the volume beam are as follows:

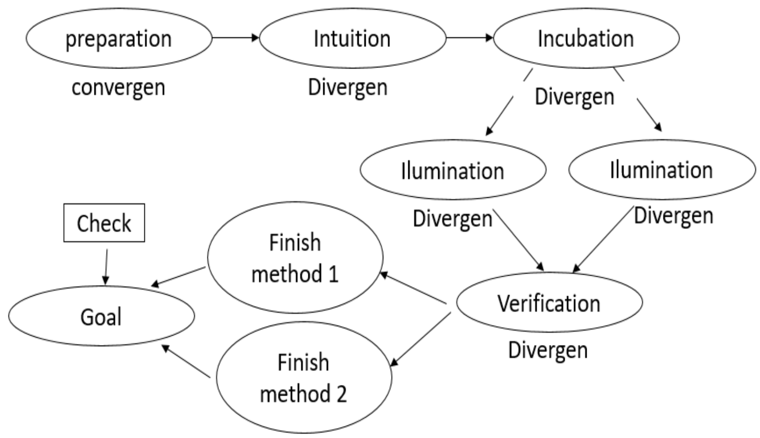
FIGURE 4
CALCULATION OF THE VOLUME OF THE BEAM IN SHAPE 1 IN A SECOND WAY



Based on the picture above, the subject uses the concept of block volume to work on the problem in a second way. Buildings 1, 3, 9, and 11 verify that the sum of the volumes of blocks is $4x162\ cm^3 = 648\ cm^3$, builds 2,4,5, 6, and 7 are $3cm\ x\ 6cm\ x\ 3cm = 54cm^3$, so the total volume of the shape is $5\ x\ 54\ cm^3 = 270\ cm^3$, and in the final figure for shapes 8 and 10 it is $9cm\ x\ 3cm\ x\ 3cm = 81cm^3$ with a total volume of $81cm^3 x\ 2 = 162cm^3$ In the final stage of verification, the total volume of the beams in method one and method two produces the same amount, $1.080cm^3$.

Based on the results above, students' creative thinking processes can be made into the following scheme:

FIGURE 5
SCHEMATIC OF SUBJECT R1'S CREATIVE THINKING PROCESS



According to Figure 5, the creative thinking process of subject R1 has been completed successfully. Then demonstrates that the subject satisfies the indicators of fluency, flexibility, originality, and elaboration. Thinking allows R1 to carry out a preparatory process that identifies questions; following this, the intuition stage, with one reading of the subject, can find out the answers and what steps to take with divergent thinking. However, the matter was silent before rereading the questions at the incubation stage so that they could get ideas by writing down the ideas that emerged during the illumination stage. R1 uses the concept of the volume of a cube and the concept of a volume of a block.

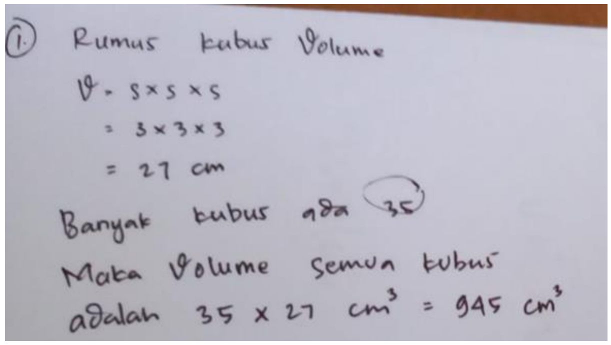
Regarding the verification stage, the subject uses divergent thinking to generate numbering to make completion easier. The arithmetic operations that the current topics are performing are carried out in a manner that is consistent and detailed. Completion of the first step by establishing the formula for the cube and fulfillment of the second step using the procedure for the beam. Not only that, but the subject operates in a manner distinct from other topics.

Concerning the subject of IM, the process starts with the preparation stage. The participant began identifying questions by writing down the known ribs three centimeters apart. The method of determining the subject does not have any confidence in the questions being asked. Based on the findings of the interviews conducted during the stage of preparation, the participants expressed their trust by asking the researchers:

IM:	"Are all volumes queried?"
Researcher:	"Yes"
IM:	"Does it also count what is in this shape?" (pointing all over)
Researcher:	"Yes, from these figures, what shapes can be formed?"
IM:	"The shape is cube-shaped".

At this point in the topic preparation, IM could not identify the problem in any significant detail. Based on the intuitive nature of the IM process, the participant could deduce that the question was seeking volume. During the incubation phase, the test subject will begin to take periodic breaks, during which they will count the number of cubes. During the stage of illumination, the issue is given an idea of how to complete the task. The IM subject verification stage can be seen in the following figure:

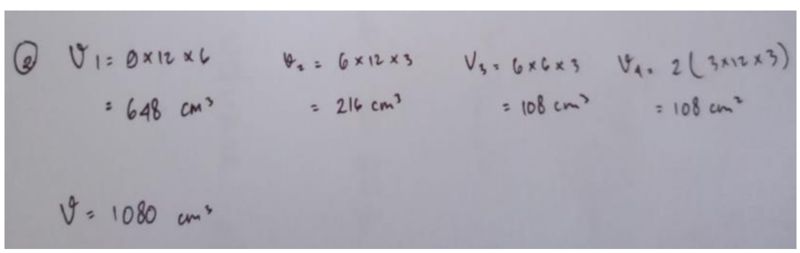
FIGURE 6
CALCULATION OF THE VOLUME OF THE CUBE IN SHAPE 1 IN A FIRST WAY



Interviews were conducted to explore the results of the IM subject's work. In the first method, IM quickly made preparations that the number of cubes was 35 pieces. The process of calculating subject cubes only looks at the number based on the lines that form the cube, so the subject preparation process needs to be more thorough. In the incubation stage, he was silent for a moment, and without thinking for a long time, the subject made calculations by finding the volume of the cube. The issue caused a mistake at the verification stage because the matter needed to be more careful in calculating how many cubes. So the results obtained are wrong.

In a second way, the IM subject carried out the process of identifying questions. Based on intuition, infer the number will be equal to way one. The incubation subject stays silent for a moment and then compares waking one with another. so that an idea is obtained that the image is in the form of a beam using the formula $p\ x\ l\ x\ t$. The calculation results can be seen in the following figure:

FIGURE 7
CALCULATION OF THE VOLUME OF THE CUBE IN SHAPE 1 IN A SECOND WAY



According to the findings, the IM subjects did not meet the criteria for the flexibility. The IM subjects in the preparatory stage needed to be more thorough in creating mathematical thinking. Hence, they needed to identify the questions, and there were still mistakes that did not match the expected results. It caused the process not to produce the desired outcomes. The first stage of intuition only requires one reading of the material to determine the answers and the following steps; however, the second stage of intuition goes differently than planned because the initial conclusions lead to different final results. The subject briefly and directly carried out the illumination stage while they were in the incubation stage, proving that the search for ideas is based on intuition. At the verification stage, the subject at the beginning of the preparation had made a mistake, so the verification of the matter went through the incubation and illumination stages.

According to the research in this area, it has been discovered that to engage in mathematically creative thinking, one must first examine the intuitive stages present in each individual. The results of his investigation and application to the incubation, illumination, and verification processes will determine the next step of the contents based on proving the truth.

RESEARCH DISCUSSION

This research aims to analyze how students conceptualize mathematical problems uniquely. In this study, we examine how creativity can use to address challenges in the field of mathematics. Students with reflective and impulsive cognitive styles will be able to compare and contrast their strengths and weaknesses in the mathematical creative thinking process.

Students have the opportunity to select questions during the preparation stage of the process. At this stage, students can analyze what is known and asked in the questions (Purnomo et al., 2022). Students who are reflective during the preparation process can identify questions, which, despite being a slow process, makes it easier to move on to the next step. Students who are overly eager during the preparatory stage tend to be in a rush, which leads to carelessness when it comes to identifying questions.

This research produced findings of a mathematically creative thinking process, specifically a process of coming to conclusions during the intuitive stage of the process. It is demonstrated by the fact that the subject draws conclusions first, then proceeds to use the verification stage to perform calculations on the outcomes of these conclusions. The final stage of verification is crucial. At this stage, students do the coding on the image. The modeling helps students in solving problems (Stender & Kaiser, 2015).

In creative thinking, there is a relationship between Convergent and Divergent Thinking. Convergent is a prerequisite for divergent Thinking (Croplay, 2006). Androutso & Brinia (2019) argue that the design process for solving problems is based on divergent and convergent reviews for the definition and solution of a problem.

In light of this, the research findings indicate that students with a cognitive style known as reflective can answer questions about creative thinking skills by going through the creative thinking processes known as preparation, intuition, incubation, and verification. During this time, students with an impulsive cognitive style have yet to be able to solve mathematical creative thinking ability questions because, during the preparation stage, students are quick but incorrect in identifying questions according to the characteristics of impulsive students, who are fast but inaccurate.

According to this, students with an impulsive cognitive style require additional attention and help from their teachers to complete their assignments. For students to become accustomed to working on coherent and coherent questions through mathematical creative thinking processes, teachers can apply strategies or make learning innovations based on the characteristics of students with an impulsive cognitive style. These strategies and innovations can find in students with an active cognitive style.

CONCLUSION

In light of the findings presented here, individuals with reflective and impulsive cognitive styles can find answers to questions through preparation, intuition, incubation, and verification. It is in line with the characteristics of students who utilize the appropriate strategies for settlement. A student with a cognitive style known as reflective can solve problems by demonstrating indicators of their ability to think creatively. At the verification stage, students can provide coding on known shapes. Students with an impulsive cognitive style have not been able to solve creative thinking questions but have yet to fulfill the flexibility stage. The evidence in the preparation process needs to be revised and lead to incorrect outcomes, following the characteristics of students who work on quick questions without being examined first. The recommendation that comes out of this research is that the process of thinking creatively and mathematically can pay attention to the intuitive process of this intuitive process, which can help students sharpen their memories based on previous learning experiences. Further research is expected to be able to describe other mathematical creative thinking processes based on different soft skills by using learning innovations so that students who are at weak points can be more motivated and can rise from their weaknesses.

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