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Student's creative model in solving mathematics controversial problems

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ABSTRACT

For students to compete with the rapid advancement in science, technology, and the arts, creativity must be more than just a necessary skill. This study of levels of creativity performed when addressing statistical issues is a follow-up to earlier studies. To heighten the degree of the creative model and produce a distinctive model, a controversial aspect was applied. Grounded theory research was the method employed in this study, which involved 178 junior high school students and a constant comparative data analysis design. The study revealed that there were five levels of creative models, in addition to the three levels of the earlier research: pre-imitation, imitation, modification, combination, and construction. The pre-imitation stage is defined by the subject's limited capacity for imitation. The level of imitation is determined by the act of copying methods even when one does not actually understand them. The modification level is essentially defined by the process of altering a procedure so that it can be applied to solve an issue. The process for merging several settings or problem-solving strategies also serves to define the level of combination. The construction level is determined by the process of developing new methods to handle problems. In this study, five new levels were discovered, and teachers can utilize these levels to assess students' degrees of creativity.

Keywords: creative model, controversial, level of creative

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INTRODUCTION

Creativity has emerged as an essential skill for preparing new coming generations to face the challenges of a globalized world. Only creative people can become change and development innovators and initiators. Creativity is also extremely important to the advancement of science, technology, and art (Science). The development of information technology capable of simplifying today's challenges is an example of human creativity. Several scientists have investigated the significance of creativity, especially in the practice of mathematics education. This is in line with the purpose of mathematics learning as a vehicle for developing reasoning and thinking skills to become good problem solvers. As a result, it is used in mathematics to develop higher order thinking skills (HOTS). One of the highest forms of intelligence is creativity.

Learning mathematics is a reasoning and logical thinking activity, especially for students who have advanced thinking skills. Creativity is the highest level of thinking, according to Bloom's Taxonomy (revised). A creative thinker can be an effective problem solver (Baran et all, 2011; Elgrably, Haim, and Roza Leikin. 2021), initiator, and innovator. The importance of creativity has prompted numerous studies, ranging from the classification of creative and critical thinking elements to the level of creative thinking. According to Joklitschke, et al. (2021) creative thinking investigation through mathematics education is expanding and the study area is broadening. Schindler & Lilienthal (2020) stated the same thing, that students' creative processes in mathematics are increasingly becoming a concern in mathematics education research. Fluency, flexibility, and originality are used by Tabach & Friedlander (2013) and Kattou et al. (2013) to analyse creativity and found that creativity and mathematical aptitude are positively correlated. According to Sriraman, et al. (2013), there are four steps to the creative process: preparation, incubation, illumination, and verification. Multiple Solution Tasks (MSTs) were employed by Schindler & Lilienthal (2020) to foster and assess students' mathematical creativity. The use of Problem Posing via Investigation (PPI) to solve mathematical problems is explored by Leikin & Elgrably (2022) in their study of the creative process and creative output. Elgrably & Leikin (2021) shown that when someone completes the PPI creativity test, problem posing and problem-solving cannot be separated.

This study addresses the topic of creative thinking from a different angle, tracking the thoughts that are based on the cognitive process of creative development, also known as the creative model. The investigation of this creative model is an extension of the work by Subanji et al. (2021), which led to the discovery of three creative models: creation, modification, and imitation. An "imitation" cognition process, or the ability to just replicate the completed process, is what distinguishes the "imitation" creative model. The process of cognition "changing" processes to fit the challenges at hand is what distinguishes the model creative "combination". Someone who is at the "modification" level cannot create new solutions methods when the problem is genuinely "new" and has never been noticed previously. Finally, being at the "creation" stage is indicated by a cognitive activity, such as developing "new" methods or approaches for resolving issues. The three outcomes continue to be developed and used in the mathematics classroom and remain extremely likely to occur. According to Subanji et al. (2021), controversial issues are problems that are unique from common and accepted problems and require rational and logical arguments to resolve. According to a study by Subanji et al (2021), the three levels of the creative model still provide opportunity for improvement.

Although To address challenges in daily life, one must use creativity. Mathematical activities can foster the development of creative thinking (Baran et al., 2011; Brunkalla, 2009; Nadjafikhah et al., 2012; Sharma, 2014; Sriraman, 2009; Švecová et al., 2014; Voica & Singer, 2012). This is premised on the notion that logic-based concepts, structures, and interactions are central to mathematics. In mathematics, logical and methodical reasoning are used to develop truth. High-level thinking calls for pupils to use their critical and inventive thinking skills when completing mathematical exercises.

Problem-solving is highly associated to creative thinking, that occurs notably in mathematical activities (Baran et al., 2011; Chamberlin & Moon, 2005; National Council of Teachers of Mathematics, 2000; Sriraman et al., 2013). According to National Council of Teachers of Mathematics (2000), it is suggested that students be given difficult problems that can encourage mathematical creativity. According to research by Baran et al. (2011), problem-solving skills are a good indicator of mathematical creativity. For non-routine problem-solving, Chamberlin & Moon (2005) discovered originality in mathematicians' thought processes. Beghetto & Karwowski (2018) also makes the case that routine practice needs to be balanced in novel and imaginative ways. Teachers might accomplish this balance by converting routine activities into non-routine challenges.

Studying creative thinking is extremely fascinating since it is necessary to deal with issues marked by worldwide development (Aurelia, 2021; Beghetto, 2017; Dwi et al., 2022; Sriraman & Dickman, 2017). It is essential to assess creative thinking according to how it is formed to measure it using its process characteristics.

The focus of this study is on the cognitive process of creative development, also known as the creative model, which explores creative thinking from a different angle. The investigation of creative models is an extension of the work of (Subanji et al., 2021), who identified three types of creative models: creation, modification, and imitation. The general creative model, as indicated in Table 1, serves as the foundation for the mathematical creative model.

Numerous experts have studied mathematical creativity. To evaluate students' creativity in solving mathematics problems, Lin & Cho (2011) developed a model of creative problem-solving ability. According to gender, Baran et al. (2011) discovered a link between creativity and mathematical prowess. According to Voica & Singer (2012), pupils with a strong grasp of mathematics exhibited strong inventiveness. Using Model-Eliciting-Activities, Coxbill et al. (2013) create and monitor students' mathematical creativity (MEASs). The association between creativity, problem posing, and problem-solving was discovered by Elgrably & Leikin (2021) using Problem Posing via Investigation (PPI). When Schoevers et al. (2022) looked at how creativity relates to solving open, non-routine tasks, they discovered that students who had higher levels of creativity were more successful at solving these types of problems.

Table 1. Creative model framework (Subanji et al., 2021)

Creative Model	General Creativity	Mathematical Creativity
Imitation	Imitating a product with a simpler process or lower cost.	Just imitating a similar form of resolution to solve the problem at hand.
Modification	Changing the function/benefit/ form of a product so that it becomes a new product.	Changing the problem/data/ resolution procedure so that it gets a more efficient solution.
Construction	Creating a new work that is more interesting, more practical, and has more functions.	Constructing a new resolution procedure in accordance with the demands of the problem.

Mathematical problems that encourage students' mathematical creativity typically to be open-ended, enabling students the opportunity to come up with novel solutions (Nadjafikhah et al., 2012; Švecová et al., 2014). Typically, creative thinking-sparking issues come in the form of several possible resolutions (Sriraman, 2009). In this project, a controversial problem that requires logical reasoning and a variety of solutions is used to devise and create a creative model. This is premised on the fact that the issue is controversial, requiring a reasonable approach and a variety of ways to address it.

Several researchers have investigated controversial reasoning. When challenged with incorrect, controversial arguments, Mueller et al. (2014) study looked at how students argued. According to Simonneaux & Simonneaux (2009), students' reasoning was influenced by their experiences whenever students confronted controversial problems. This could also exist in the context of mathematics if there is a disagreement between the present circumstance and the mathematical knowledge that is possessed.

The existence of a controversial problem encourages one to recognize the presence of a controversy or contradiction, explore the contributory factors, and afterwards clarify. In this scenario, Subanji et al. (2021) study of controversial reasoning indicated that it comprises three levels: initial, exploratory, and clarification. As a higher order thinking activity, controversial reasoning can be investigated and employed to develop earlier models.

METHOD

This is grounded in theory research with constant comparative data analysis design (Creswell, 2012). This research develops theory by refining the level of the creative model that has been developed by Subanji et al (2021). The characteristics of smoothing the level are obtained from the results of fixed comparison data analysis of the subject's creative behavior in solving controversial problems. To examine the creative activity of the students according to the study, the researcher in the present case poses controversial questions regarding the geometry material. This study examines the creative thinking level of 178 junior high school students in Malang City in solving controversial problems on the topic of geometry. The study began by observing the classroom, learning about the perimeter and area of geometric shapes. The perimeter material has been given since the fourth grade and the area of shape geometry has been given in the fifth grade of elementary school. These two materials were discussed again in grade VII Junior High School, with one basic competency being calculating the perimeter and area of triangles and quadrilaterals and using them in problem solving. Class VII and VIII students were observed as students studied about the circumference and area of geometric shapes. It was observed that the following steps were utilized in the learning process: the definition of circumference and area; examples of perimeter and area; and practice exercises for applying the concepts of circumference and area. Some of the formal and practical formative questions are related to everyday life. The development of the assessment used to confirm the concepts of area and circumference is more normative, such that all concepts are in line with reality. Students very hardly ever see a controversial topic from daily life and material while studying at the same time.

The research instrument developed by the researcher exposes the disagreement between students' experiences in everyday life and the studied mathematical concepts in context of the problem that has been mentioned above. Table 2 is a depiction of the instrument's development and related discussions.

Problem 1: Perimeter

Mr. Budi asked his two nephews, Adi, and Ali, to help determine the perimeter of his garden, which has been made up of plots per square meter. Adi determines the circumference by walking around the garden. Each pass through a square is numbered sequentially. Adi concludes that the circumference is 26 meters. Ali determined the circumference in a different way, starting with determining the length and width, then using the circumference formula, the result was 30 meters. After getting reports from his two nephews, Mr. Budi became confused because they both made sense but were different. Please help Pak Budi to determine the correct answer by 1) Explain why the two methods can produce different answers! 2) Explain what is right and what is wrong. 3) Explain the reason why the answer is right or wrong. And Figure 1 is the perimeter.

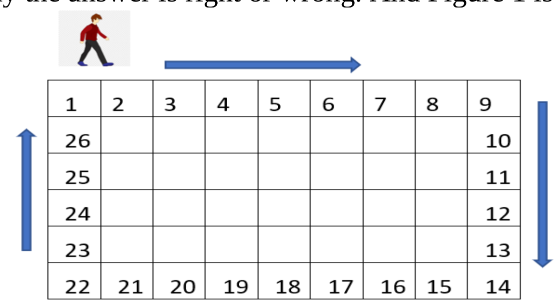

Figure 1. Mr Budi Perimeter's Garden

Problem 2: Elderly Gymnastics

An elderly association will hold mass gymnastics in an open field (Figure 2). The committee divided the field into 2 parts: for instructors and for participants. The field for participants is 23×25 m^2. The committee makes a rule that the minimum space for each person is 2×2 m^2. The committee wants to ensure the maximum capacity of participants that can be accommodated in the field. Several committee members (Adi, Bowo, Cika) had different opinions in determining the maximum capacity by using different arguments.

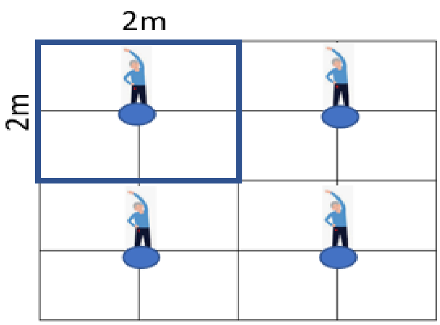

Figure 2. The Mass Gymnastics

Adi believes that the maximum capacity is 144 people, because the max capacity = $(23 \times 25) : 4 = 143.75$. By rounding up, we get 144. So, the maximum capacity is 144 people. Bowo refuted Adi's opinion that 143.75 cannot be rounded up because it is related to humans. It should be rounded down, so the maximum capacity is 143 people. Cika disagreed with her two friends, that the procedures used by her two friends were not appropriate. Based on Cika's intuition, the maximum capacity is only 132 people, but Cika cannot explain it to her two friends. In your opinion, are the answers from the three committees, correct? If this is true, please explain! If none of the opinions are correct, give the answer that you think is appropriate!

Problem 3: Area

Pak Broto is a chicken farmer, has a rectangular chicken coop measuring 15×5 m^2 which can accommodate 45 boxes of chickens, where each box contains 2 chickens (Figure 3). Between the rows of chicken boxes there is a passage (as shown below). There is a wall around the chicken coop. The longer the circumference, the greater the cost of making the wall. Mr. Broto thought of making savings in wall construction. Mr. Broto wanted to design a cage with a smaller circumference but a larger area than the cage above. To discuss his wishes, Mr. Broto invited two of his younger brothers to discuss, namely Mr. Suto and Mr. Noyo. Pak Suto is of the opinion that if the circumference is smaller, then the area must be smaller. Pak Noyo has a different opinion that it is still possible to make a rectangle with a smaller perimeter and a larger area than the rectangle above. You were asked for help by Mr. Broto in deciding which of his sister's opinions was correct, give a reason! (Can make alternative pictures).

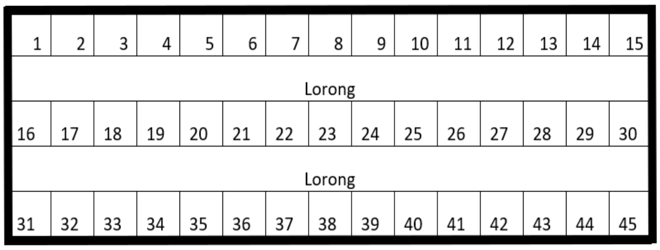

Figure 3. Rectangular Chicken Coop

Table 2. Depiction of the instrument's development and related discussions

Problems	Elements of controversy/mental model
Problem 1: Perimeter	In daily life, students are often asked to circle the floor of a room in their house and construct the perimeter by counting the number of tiles that surround the floor. This is different from the concept of circumference. *To measure pre-imitation and imitation mental models*
Problem 2: Elderly Gymnastics	In learning mathematics about math story problems, there are often examples of problems regarding the distribution of inherited land (rice fields, fields, or plots of land) to several people. The division that is often done is to calculate the area of land divided by the number of people who are given a share. In this controversial issue, there is a variable conditional distribution that 1 person must occupy a size of 4 m^2 with a size of 2×2 m^2. *To measure the creative model of imitation-modification-combination*
Problem 3: Area	Most students perceive that the relationship between circumference and area is linear, meaning that the larger the area, the greater the circumference and vice versa. The controversy that is built on this problem is that with a smaller circumference, a larger area can be obtained. This can happen if the length and width are set so that they are close to a square shape. *To measure the construction creative model*

In-depth interviews were then conducted after grouping student work results for the three problems in relation to the creative model framework. By selecting, paying attention, adjusting, and abstracting data, the results of work and interview data are minimized. Coding comes next, and it's done by hand. Data visualization and conclusion-making are the following steps. An analysis of fixed comparison data is used to identify the characteristics of the additional level. New levels of the creative model are being developed by further examining creative characteristics that aren't included at the three levels of the model. Data analysis with constant comparison is employed to identify the characteristics of the new level additions.

FINDING AND DISCUSSION

Finding

The results of the students' work in solving controversial perimeter and area problems are categorized into three possible levels of creative proposed model: imitation, modification, and creation. There are certain answers that, after further examination, cannot be accommodated into the three creative models that already exist. The creativity of such students nevertheless comes short of imitation. Due to their inability to "imitate" the approaches they have already learned, students have begun to examine problems successfully and can recognize any controversies, but they have not yet been able to describe which solution is the most appropriate. They are referred to as pre-imitation creative models in this study since they have not yet reached the imitation level.

Subjects who can combine various procedures to create new procedures and solutions are at the level above modification. The stages for this level, also known as the combination level creative model, involve: The area combines the techniques that have been found with the actual data that serve as the problem's point of reference. By combining one of them as a control to trace the difference between scientific concepts and empirical facts, the subject confronts a conflict of controversies between scientific procedures that have been obtained with empirical facts. Combining these techniques enables the subject to properly continue the problem-solving process and arrive at the ideal solution. Furthermore, a fixed comparison study was conducted to determine the features of this combination-level creative model.

Five levels of the creative model—pre-imitation, imitation, modification, combination, and construction—are obtained with the incorporation of an additional two levels. After establishing the five levels of the creative model, the participants were then divided into the following groups according to level (Table 3).

Table 3. Participants divided into groups level

Level of creative model	Class VII		Class VIII		Total
	Male	Female	Male	Female	
pre-imitation	8	9	5	7	29
imitation	13	14	9	10	46
modification	11	9	12	14	46
combination	5	7	11	12	35
construction	4	3	9	6	22
Total	41	42	46	49	178

Pre-imitation creative model

Several The subject only recognizes that the method for encircling and counting the number of squares is appropriate and reasonable but when comes to the circumference problem. Although it contrasts with the second opinion, the pre-imitation individual can calculate the circumference using only empirical data. They think it is reasonable to calculate the circumference by using the number of squares. The subject is aware of the controversy at the pre-imitation level but is unable to explain which answer is more appropriate. The subject chose the incorrect answer. In relation to the concept of the rectangle's perimeter, the subject established the method of determining the circumference by adding up each square that encircles the rectangle one at once. The statements are the answer to the pre-imitation model creative (Figure 4-6).

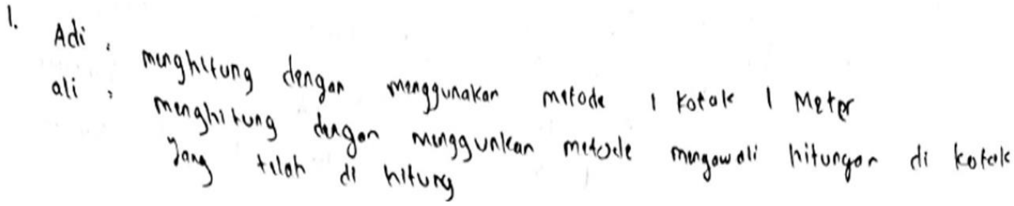

Figure 4. The Answer to the Pre-imitation Model Creative

Translation:
Adi: calculate using the 1 box 1-meter method.
Ali: count using the method of starting the count in the box that has been calculated.

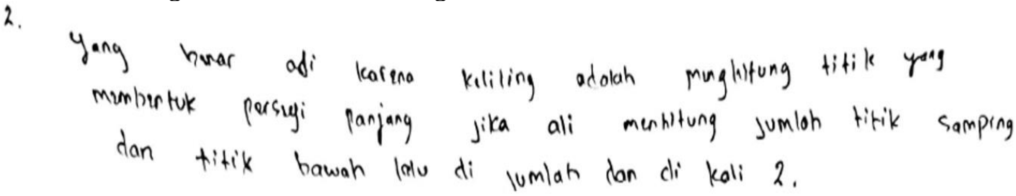

Figure 5. The Answer to the Pre-imitation Model Creative

Translation:
Adi is correct because the circumference is to calculate the points that form a rectangle if Ali counts the number of side points and bottom points then they are added and multiplied by 2.

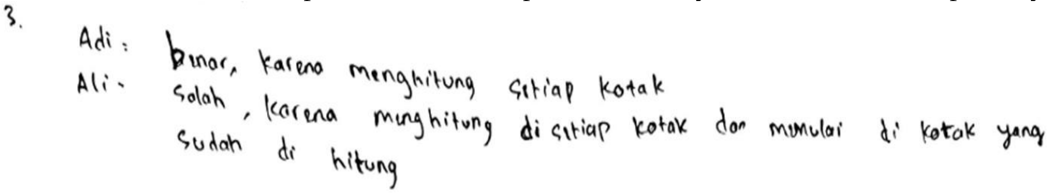

Figure 6. The Answer to the Pre-imitation Model Creative

Translation:
Adi: right because it counts every square.
Ali: wrong because it counts in every square and starts at the already counted box

Verbal explanations from subjects were effective in convincingly addressing questions. According to the subject, the correct approach was the method of computing the squares that surround the rectangle. The subject noted that there were variances in the findings since the methods utilized were different. During the in-depth interview, the subject identified the image by counting the rectangles in it one by one (Figure 7).

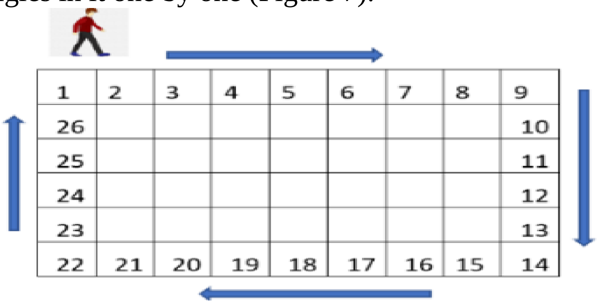

Figure 7. Image Rectangles

R: You choose that the correct answer is Adi's answer, please explain!
S: Adi goes around, from box 1 to box 2, and so on (pointing to the picture). It means to surround, and it can be called circumference.
R: If you call Ali's method wrong, explain why you call it wrong?
S: Yes, Ali counts the horizontal edge points to get 9 and the vertical one gets 6. Then multiply by 2. It does not go around but counts the points and continues to add up and multiply 2. Ali does not appear to be around. If Adi clearly surrounds.

Images are frequently used by subjects to illustrate their points. This demonstrates how a student is employing a visual moderator to make his point clear. The subject realized that the explanation was a concept of circumference even if the subject was able to explain the method used by Ali by calculating the edge points, adding the horizontal (length) and vertical (width), and multiplying by 2. Because Adi's experience seemed essential in solving the issue, the subject certainly feels that he was the one who "actually" circled the geometry of shapes. This shows the absence of a routine because the subject is unable to relate what Ali did to the method or formula applied to the problem.

Imitation creative model

The subject is aware of the disagreement on the approaches taken by Adi and Ali in calculating the perimeter of a rectangle. The imitation subject could investigate controversial topics. Adi's approach involves counting the squares that round the rectangle, whereas Ali's approach involves applying a formula. The subject of the imitation was first perplexed because, while Ali's actions were also appropriate because arithmetic is a subject that is frequently taught in schools starting in elementary school, Adi's actions made sense and were frequently encountered in daily life. This perplexity encourages imitation subjects to investigate the reasons for anomalies. Figure 8 is a list of the search results for controversy.

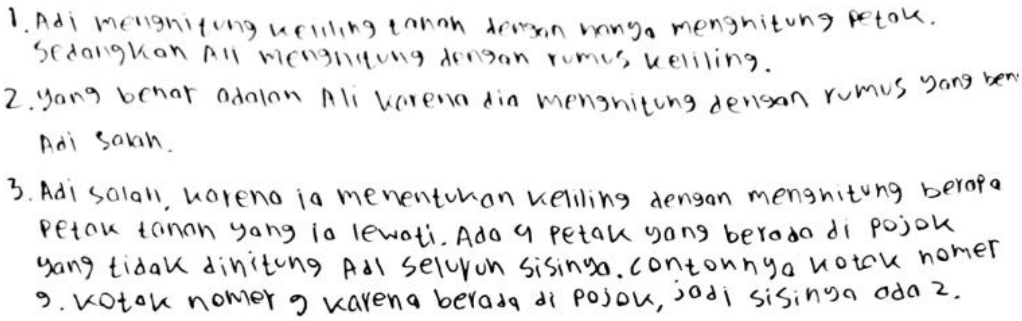
1. Adi menghitung keliling tanah dengan hanya menghitung petak. Sedangkan Ali menghitung dengan rumus keliling.
2. yang benar adalah Ali karena dia menghitung dengan rumus yang ben Adi salah.
3. Adi salah, karena ia menentukan keliling dengan menghitung berapa petak tanah yang ia lewati. Ada 4 petak yang berada di pojok yang tidak dihitung Adi seluruh sisinya. contohnya kotak nomer 9. kotak nomer 9 karena berada di pojok, jadi sisinya ada 2.

Figure 8. Results for Controversy

Translation:

1. Adi calculates the circumference of the ground by only calculating the grid. While Ali calculates the circumference formula.
2. The correct one is Ali because he calculates with the correct formula. Adi is wrong.
3. Adi is wrong, because he determines the circumference by calculating how many grids of land he will pass. There are 4 squares in the corner which Adi does not count the rest of. For example, grid number 9. Grid number 9 because it is in the corner, so there are 2 remaining.

The confused imitation subject assumed Ali was right because the equation $K = 2p + 2l$ was frequently employed in class instruction. He believed that the formula he had learned in school could not possibly be incorrect. Through in-depth interviews, researchers examine the cognitive functions performed by imitation respondents.

R: Please explain what you mean by writing an answer like this! In your opinion, which one makes more sense, between Adi and Ali's answer?

S: At first, I thought Adi's method made more sense, because calculating the circumference is done by going around, and that's usually done when asked to go around the garden. However, what Ali did was also correct, because it used a formula that I often got at school. Then I became confused, both make sense, but how come they are different. This problem is weird.

R: When you start to feel weird, what do you do?

S: I believe the correct one is the formula

R: why?

S: because the formula has been given at school, it can't be wrong (imitating the one at *school is supported by belief).*

R: When you are more sure which formula is more correct, what do you do?.

S: I tried to trace again, which part is causing the difference. Starting from square one, to square 2, continue until square nine (Subject shows the picture)

R: What did you find from that search?

S: This corner should be counted twice.

Because it matches the answer that was previously found at school, the imitation topic can explain why its solution is more appropriate. With the formula $K = 2p + 2l$, the imitation subject has already grasped the concept of a rectangle's perimeter. When imitation subjects initially started to read the questions, they did think the method of calculating the number of squares surrounding a rectangle was very reasonable, but when the results differed from calculations using formulas, they tended to put more belief in the standardized formulas they had learned in elementary and junior secondary school. The issue of "duplicating" the formula given in school stimulates further investigation of the differences in the outcomes. The imitation subject can trace the distinctions between the two methods used to calculate the circumference, and the subject is also able to explain the elements of the controversy that exist in the problem, which is reflective of word use from the commognitive perspective. The dominance of the belief that the formula is more accurate since it utilizes the method of "imitating" that was taught in school. The formula is imitated and compared with the problem's constituent elements on the assumption that it is more accurate than the components. To assist with the process of tracing the components in the image, the imitation subject often shows pictures and drew on the image in the visual aspect of the mediator. In terms of routine, imitation subjects who use the selected settlement procedure tend to be based on the obtained trying to imitate process, which is that they believe the formula they were taught in school cannot be wrong, so they use that formula as a starting point to learn more about this controversial subject.

In the second problem with old gymnastics, the imitation subject imitates the standard school-taught division procedure. If one person requires 2×2 m^2 = 4 m^2 and the field's area is 23×25 m^2 = 575 m^2, then $575 : 4$ = 143.75 persons can occupy the field. The following imitation procedure attempts to imitate the rounding of 0.75 to 1, resulting in 144. However, the setting of this argument is recognized to be human, therefore the imitation subject assumes that 0.75 cannot be chosen by body form. The subject therefore determines that the maximum capacity is 143 individuals. Figure 9 is the imitation answers to the topic of elderly gymnastics.

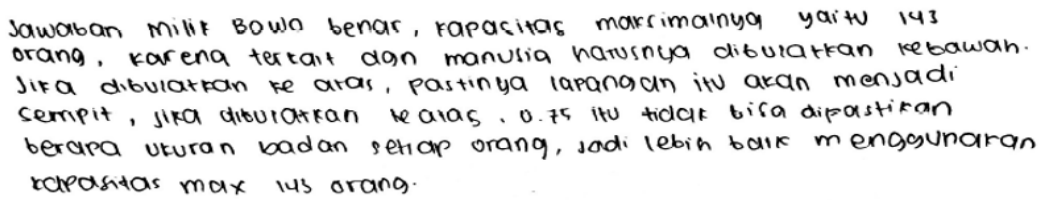
Jawaban Milik Bowo benar, kapasitas maksimalnya yaitu 143
orang, karena terkait dan manusia harusnya dibulatkan kebawah.
Jika dibulatkan ke atas, pastinya lapangan itu akan menjadi
sempit, jika dibulatkan ke atas, 0.75 itu tidak bisa dipastikan
berapa ukuran badan setiap orang, jadi lebih baik menggunakan
kapasitas max 143 orang.

Figure 9. The Topic of Elderly Ggymnastics

Translation

Bowo's answer is correct, the maximum capacity is 143 people, because it is related to humans it should be rounded down. If rounded up, surely the field will be narrow. If it is rounded up, 0.75 cannot be ascertained what each person's body size is. So, it's better to use the maximum capacity of 143 people

Through in-depth interviews, the following is an in-depth look at how imitation subjects come up with ideas.

R: Why did you choose Bowo's correct answer, that the maximum number that can occupy the field is 143 people?

S: Since the size of the field is 23×25 m^2, the area can be calculated, which is 575 m^2. Since one person needs 2×2 m^2 = 4 m^2, the maximum number is $575 : 4$ = 143.75 *people. I have often learned this from studying division in mathematics.*

R: You rounded 143.75 to 143. Is that how you round it?

S: Actually, in the correct rounding, 0.75 should be 1, 143.75 should be 144. However, because it is related to humans, 0.75 people (think a little longer), it is difficult to interpret. It may be small people, but it is still impossible. Therefore, I consider it more appropriate if it is rounded up to 143 people.

R: Do you think Cika's opinion that the maximum number of 132 people is reasonable?

S: I think Cika's opinion doesn't make sense.

It appears, based on these in-depth interviews, that the imitation subject imitates the procedures commonly found in schools, such as dividing the whole by the division. The imitation subject is incapable of recognizing that other variables impact the solution to the problem. The imitation subject is unaware that a person's space must measure 2×2 m^2 and cannot be represented by 1×4 m^2, even though that $1 \times 4 = 4$ m^2.

Modification creative model

The problem of elderly gymnastics is used to describe the modification creative model. Subjects at the modification level are aware of the controversy involving the requisite that 1 person requires a space measuring $2 \times 2 = 4$ m^2. The size of the field is 23×25 m^2. Commonly, the number of people is calculated by dividing the area of the field by the required location for one person. However, the subject began to understand that 4 m^2 could be produced from either 2×2 m^2 or 1×4 m^2. He modifies 4 m^2 to 2×2 m^2 and 1×4 m^2, and then analyses the two feasible solutions, both of which are 2×2 m^2, because this is a fair compromise for a gym room. This subject, armed with the 4 m^2 modification, concludes that the length and width must be equal. The utilizable length of 25 meters is 24 meters, and the accessible width of 23 meters is 22 meters (Figure 10).

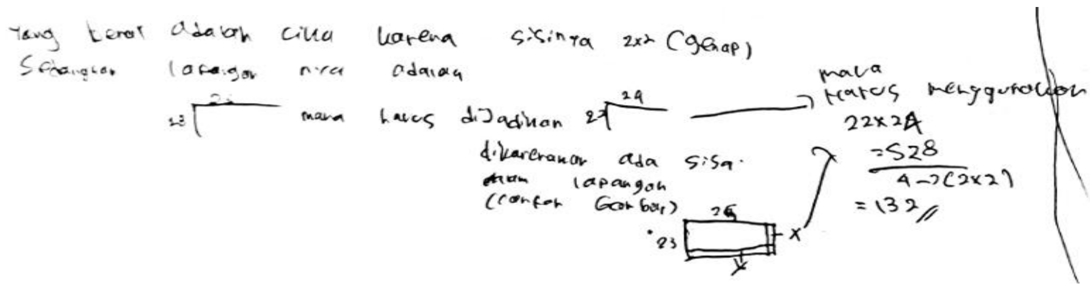

Figure 10. The Subject's Answer

Translation

The correct one is Cika because the sides are 2×2 (even). While the size is 23×25, it must be made 22×24, where there is 1 remaining that cannot be used. The maximum number of people participating in the gymnastics is $\frac{22x24}{4} = \frac{528}{4} = 132$ people.

Based on the subject's answers, task-based interviews were conducted to learn more about his creative thinking.

R: Did you think from the start that Cika's answer was the most correct? Please explain it to me!

S: No, I initially thought Bowo's answer made sense, because the area of the field is divided by 4 m^2

R: When did you start to think that Cika's answer was the most correct?

S: When I saw that the size of 1 person needed 2×2 m^2, then I matched it with the field conditions, it didn't fit. Although 2×2 m^2 = 4 m^2, 4 m^2 can also be produced from 1×4 m^2. It seems unreasonable that gymnastics uses a field measuring 1×4 m^2, the movements can crash.

R: You are trying to modify 4m2 as 2×2 m^2 and 1×4 m^2. What affects the 4 m^2 can be produced from the 2×2 m^2 and 1×4 m^2?

S: In effect, the sides must be even. It can't be odd. Therefore, the size of 23×25 *m*^{2} *that can be used is only* 22×24 *m*^{2}.

To enhance the clarity of the explanation, the modified subject redraws the field and determines the size and remaining part of the edges. Using the example in the problem that one person requires a 2-meter-by-2-meter field, the subject matches it with the image of the field (Figure 11).

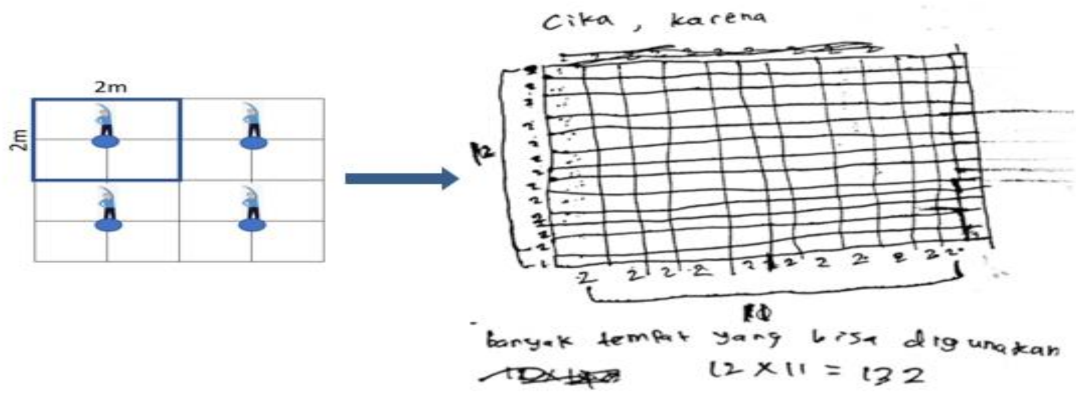

Figure 11. Subject of Modification Level Draw the Explanations

The imitation subject's capacity to explain the argument, modify the 4 m^2 strategy as 2×2 m^2 and 1×4 m^2 based on an equitable compromise, and modify the technique to get a more appropriate response. The subject also utilizes a *visual mediator* in the form of images that are provided to clarify the strategy change process to make the argument more convincing. In the context of the *routine*, the subject reduced the length and width gymnastics participants could occupy from 23×25 m^2 to 22×24 m^2. The change in size was chosen because the field had to be an even size, and it might define the maximum number of gymnasts who could perform on the field.

Combination creative model

The subject in the level of combination begins the solution by observing each side of the field-representing rectangle. This topic begins by observing the empirical condition of one individual requiring 2×2 m^2 and relating it to the rectangular condition. Based on the assumption that a single individual occupies a 2×2 area, the combined subject employs two strategies. First, he divides the 25-meter-long side by 2 meters to get 12.5 and concludes that 12 people can occupy the remaining meter in the long direction. Second, in the wide direction, he divides 23 m by 2 m and obtains 11.5, which he interprets to mean that 11 people can occupy the remaining 1 meter in the wide direction. Combining the two strategies, the maximum number of people who can occupy the field is $12 \times 11 = 132$. Thus, the most accurate response is Cika's, who answered purely based on instinct, but still it turned out to be correct (Figure 12).

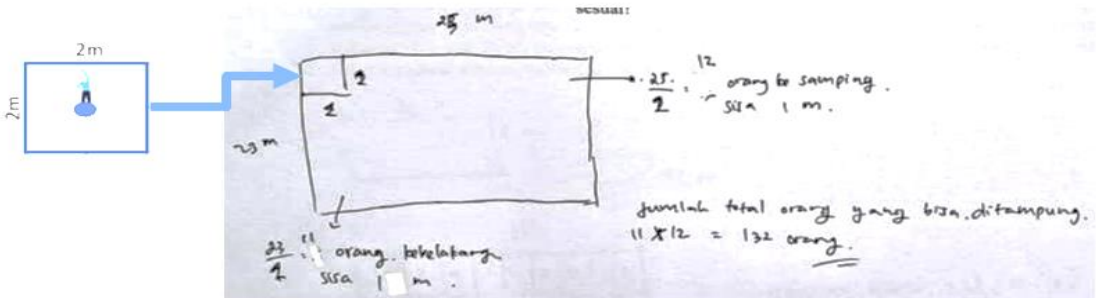

Figure 12. Combination Subject Level in Drawing Explanations

The combination subject clarifies the description of the answer by stating that $11 \times 12 = 132$ people can participate in gymnastics based on mathematical calculations with a field size of

23×25 m^2 and 1 person occupying 2×2 m^2. Thus, there are remaining fields measuring 1×23 m^2 and 1×25 m^2 that participants cannot occupy because there is insufficient space for movement (Figure 13).

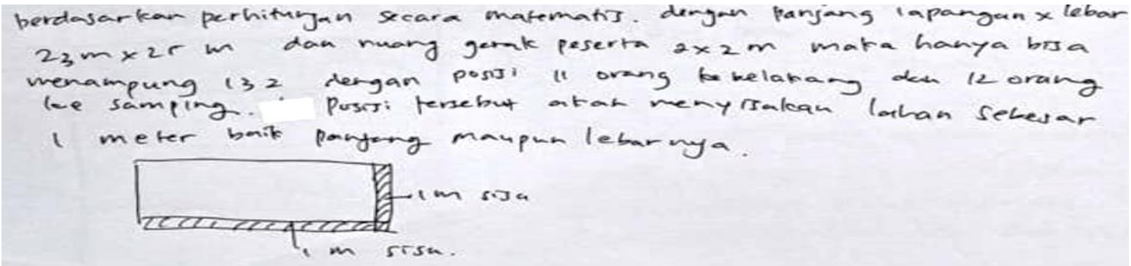

Figure 13. The Creative Thinking Processes

Translation

Based on mathematical calculations with the length of the field x width = 23×25 m^2 and the space for participants to move 2×2 m^2, it can only accommodate 132 people, with 11 people on the back and 12 people on the side. This position will leave 1 meter of lava both in length and width.

The researcher conducted in-depth, task-based interviews to explore the creative thinking processes of combination subjects.

R: How can you determine the maximum number that can occupy the 23×25 *m*^{2} *court?*

S: I noticed that one person takes up 2m on the right and left and 2m on the front and back. When the length is 25 meters, it means that what I use is 2m left and right, then I divide 25 by 2, and I get 12.5.

R: What does 12.5 mean?

S: This means that in the right and left directions (horizontally), 12 people can be filled and there is still half left, meaning half the people. Because if 1 person needs 2 meters to the right, then half of this person means there is 1 meter left and this cannot be occupied by one person. So only 12 people.

R: How did you get 132 people?

S: In the second strategy, I focus on the width (front-back). In the same way, I get a maximum of 11 people to occupy the space from front to back. By obtaining the maximum number of people in the direction of length 12 and in the direction of width 11, then the total number of people is 12 x 11 = 132 people.

Subject describes two strategies used to determine the maximum number of gymnastics participants in the direction of length and width, i.e., in the direction of length, it can accommodate up to 12 people, and in the direction of width, it can accommodate up to 11 people. The topic employs a visual mediator consisting of two rectangular images. In the first image, the subject conveys the concept of describing the position of a single individual requiring 2m x 2m, which is depicted in the upper right corner of the rectangle. The second image conveys the concept regarding the remaining unused 1m x 25m and 1m x 23m fields. Concerning the routine component, the subject combined two problem-solving strategies (right-left and front-back) so that the maximum number of gymnast participants was 132.

Construction creative model

Subjects with constructive thinking analysed the components of a problem by emphasizing the key components: the size of the cage was 15 meters by 5 meters, there were 45 chicken boxes, and each box contained two chickens. The circular cage design was more compact but better built. Largely, there are two distinct viewpoints Suto contends that if the circumference is smaller, the area must also be less, however Noyo believes it is feasible to have a smaller footprint with a bigger area.

The subject redesigned the chicken coop in a unique manner by reducing the length from 15 meters to 13 meters and the width from 5 meters to 7 meters. The subject then calculates the area to be 13×7 m^2 = 91 m^2 (more than the current cage area of 75 m^2) Similarly, the maximum number of chicken boxes that can be created is 52, and if each box has two chickens, it may accommodate 104 chickens. However, it turns out that K = 2 x (17+13) = 40 m after determining the circumference (same as the existing cage) (Figure 14).

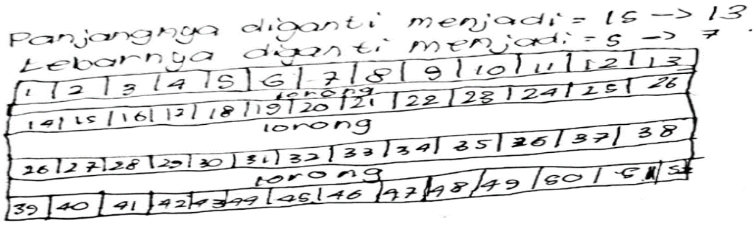

Figure 14. A Different Solution

Translation
Changed the length 15m to 13m.

After realizing that the circumference remained the same as the previous cage, the subject attempted to find a different solution by altering the size of the cage. L = 15×5 m^2 = 75 m^2 and K = 2 x (15+5) = 40 m were the recalculated dimensions of the rectangle (representing a chicken coop). Due to the incorrect circumference component, the subject had time to consider reducing the circumference to less than 40 meters. The students explored several alternatives, including 12 meters by 7 meters, 16 meters by 3 meters, 13 meters by 6 meters, and 12 meters by 6 meters. The initial option was attempted. The length is 13 meters, and the breadth is 6 meters, so the circumference is 2 x (13+6) meters = 38 meters (less than 40 meters), and the area is L = 13×6 m^2 = 78 m^2 (this is also more than 75 m^2). The subject double-checked the completed drawing. It was determined that if the length is 13 meters and the width is 6 meters, then the number of chicken boxes is reduced to 38 because the lower wall has a hallway.

The subject then calculated the perimeter K = $2\ (12 + 7) = 38$ m and the area L = 12×7 m^2 = 84 m^2 after shortening the length from 13 meters to 12 meters and broadening the breadth to 7 meters (Figure 15).

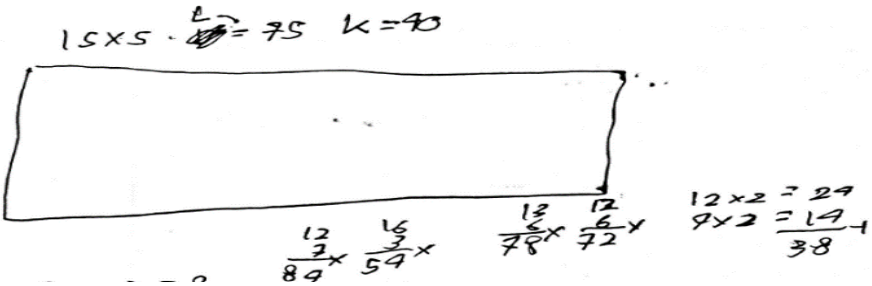

Figure 15. Recalculation of Constructive Subject Level

The subject believes the circumference is 38 m (less than 40 m) and the area is 84 m^2 (more than 75 m^2). The subject eliminates one column and draws squares 1–12 from his previous drawing. Just two lines represent that Mr. Broto wants this size (Figure 16).

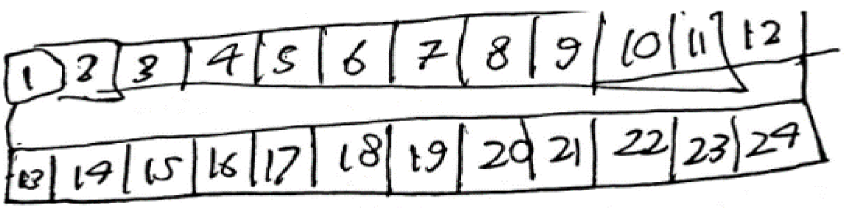

Figure 16. Redesign of Chicken Box by Constructive Subject Level

The subject only created 2 lines, although this image can be extended up to 48 like his. To comprehend creative thinking in this subject, the researcher conducted an in-depth task-based interview.

R: What did you initially think about this problem?

S: The problem is a bit strange. If the cage is made so that the circumference is smaller, the area should also be smaller. However, I suspect that Mr. Noyo's idea could be implemented.

R: What did you do after you became suspicious of Pak Noyo's idea?

S: I tried to change the size of the cage, I reduced the length from 15 m to 13 m and increased the width from 5 m to 7 m. I am happy because the area can be bigger and the resulting chicken boxes can be more, namely 52 boxes, the chickens can be 104 chickens. However, after I calculated the circumference, it was still the same as the existing cage, which was 40 m. In fact, what Mr. Broto wanted was to shorten the circumference to save the fence.

R: So, what do you do after the results don't match Pak Broto's request?

S: From the drawing strategy that I made; I believe that the size can be changed so that the circumference is smaller. I tried several alternatives (shows some tried sizes). From those alternatives, I tried to calculate the perimeter and area. The first choice is 13 m x 6 m in size. I think it is suitable because it has a shorter circumference (38 m) and a larger area, which is 78 m^2. But after looking at the picture I made earlier, if the width is even, then the lower part near the wall is the hallway. Although the area is larger, only 38 chicken boxes can be made, meaning that only 76 chickens are kept.

R: Are you still curious about making a new strategy again?

S: Yes... I reduced the length from 13 m to 12 m while keeping the width at 7 m. With this measure, the circumference is 38 m, and the area is 84 m^2. There are also more chicken boxes that can be made, which is 48 boxes. This means the number of chickens that can be kept is as many as 96.

The subject tries different cage sizes to address the problem. Details suggest subjects to communicate alternative ideas. The individual drew 3 illustrations to clarify his ideas and generate innovative ideas. The graphic also shows how the constructive theme shortens and widens. The circumference and area reduce.

Discussion

The problems presented in this study comprise controversy between students' empirical experiences and scientific concepts learned in school by presenting them in the form of word problems. The presentation of problems in the form of word problems is essential for the development of students' thinking (Brownlow, 2021). Problem solvers must comprehend the context of the problem presented verbally, change to a mathematical problem, solve the problem mathematically, and transfer the problem-solving to its original setting in the context of word problems. Problem-solving cycles like all these occur continuously, allowing problem solvers to improve their ability to interpret word problems. Cognitive conflicts that endure throughout the creative process are driven by the difference between empirical experience and scientific concepts that are presented as word problems. In order to encourage creative thinking, the presentation employs a diverse range of representations, including verbal and visual tools for problem-solving (Dagan, Satianov, and Teicher, 2018).

Various subject responses from controversial problem-solving can be categorized into three creative frameworks, including imitation, modification, and construction (Subanji et al., 2021). Nevertheless, some issues have not yet matured into "imitation" creative models. This subject is aware of the controversy about the issue but hasn't been able to identify the issue's triggering aspect. They are more persuaded by the empirical fact that he observed in his daily life—that when asked to calculate the circumference, the subject moves around and counts the number of "tiles"—than they are by other arguments. Pre-imitation is the concept for the cognitive process that is employed to construct original arguments but tends toward "imitation".

Additionally, it was observed that some subjects moved past the modification level but had not yet reached the creative level that lies between modification and construction. This subject demonstrates the behaviour of understanding the controversy, being capable of arguing the arguments for a better solution and being able to modify the process by combining empirical procedures and formulas to make problem-solving easier. Additionally, this subject belongs underneath the "combination" creative level. Consequently, the creative framework developed from three levels (Subanji et al., 2021) to five levels. Table 4 gives a description of its characteristics.

Table 4. The description of creative framework

Creative Models	Characteristics
Pre-Imitation	Be aware of the controversy surrounding the problem, but he/she has not been able to find the aspect that caused the controversy. subject begins to imitate but is still limited to the context of experience that has not yet been conceptualized.
Imitation	Recognizing the existence of controversy and being able to explain the components that cause controversy in the problem, but the specified resolution procedure is only limited to imitating what has been obtained and unable to explain meaningfully
Modification	Recognizing the existence of controversy, explaining the disagreement that exists in the problem by adjusting its components to obtain the correct solution, and being able to communicate the chosen technique in a comprehensible manner.
Combination	Recognizing the existence of controversy, explaining the disagreement that exists in the problem by adjusting its components to obtain the correct solution, and being able to communicate the chosen technique in a comprehensible manner.
Construction	Recognizing the existence of controversy and being able to create new techniques for solving problems that are simple and meaningful.

This research can be used to create studies on how to use creative models to create learning models, how to create activities that can be used to enhance creative models, and how to use contentious mathematical issues to teach mathematics. Smoothing the level of students' creative models, such as the potential for transitions between levels of creative models, is another issue that can be followed up.

CONCLUSION

The creative model is a study of creative thinking based on the cognitive process of creative formation. Based on the results of this study, three creative models were developed into five categories: pre-imitation, imitation, modification, combination, and construction. The process of "starting to imitate" the completion procedure in a limited situation, which leads to an incorrect solution, is what distinguishes the pre-imitation level of the creative model. Even though it yields the right result but is unable to effectively explain it, the imitation level is defined by the process of replicating the completion procedure that has been accomplished. The cognitive process of modifying the completion procedure to make it simpler and more meaningful is what defines the modification level. Combining various elements or processes to create new, simple-to-use processes is what is known as the "combination level." The emergence of innovative settlement procedures to address controversial problems distinguishes the construction level.

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