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Students' Creative Thinking Process in Solving Multiple Solution Tasks on Geometry Material

Refni Adesia Pradiarti*, Sudirman, & Sisworo

Department of Mathematics, Universitas Negeri Malang, Indonesia

Abstract: This research is a qualitative descriptive research which aims to explore students' creative thinking process in completing MST on geometry material. The creative thinking process of each individual is different according to their level so it is necessary to analyze how students' creative thinking process is in completing MST based on level of creative thinking. Researchers refer to the stages of creative thinking developed by Wallas consisting of preparation, incubation, illumination and verification stages. Researchers focused subjects on the 5 levels of creative thinking developed by Siswono in the stages of creative thinking, namely subjects with levels of creative thinking level 4 (very creative), 3 (creative), 2 (quite creative), 1 (less creative), and 0 (not creative). Each level is described starting from the preparation, incubation, illumination and verification stages. Based on the research results, there are differences in creative thinking processes at each level of creative thinking, especially at the verification stage, only students with creative levels 4, 3, and 2 carry out the verification stage; The incubation stage for students with creative levels 2, 1, and 0 takes a long time so that subjects with a long incubation stage are not optimal in completing MST to get many alternative solutions.

Keywords: geometry, multiple solution tasks, creative thinking process.

▪ INTRODUCTION

Creative thinking is very important for students to come up with innovations, work on original ideas, and find new ways of thinking (Schindler & Lilienthal, 2020). The process of producing something new can be meaningful learning (Schoevers et al., 2022) as well as being a benchmark for the success of mathematics learning (Rachmantika et al., 2022). Creativity in mathematics is a complex phenomenon that can be viewed from multiple perspectives (Leikin & Sriraman, 2022). Gridos & Avgerinos (2022) put forward several research focuses on creativity which include (a) stages of the creative process, (b) characteristics of creative actions and products, (c) personality of creative individuals, and (d) cognitive processes involved in creative activities. General indicators used in various studies to measure creativity according to Silver (1997) are fluency, flexibility, originality. Developing creative thinking skills is essential to prepare students for the world they will live in in the future (Mumford & England, 2022) especially to face the increasing competition in life (Rudyanto et al., 2019).

Students' creative mathematical thinking abilities can be seen in the problem solving that students create (Aisy & Kurniasari, 2019) and is referred to as creative problem solving. Creative problem solving involves both types of thinking, namely divergent thinking and convergent thinking (Van Hooijdonk et al., 2023). In addition, students' prior knowledge is needed to understand problems well and generate creative ideas to solve them. According to Alimuddin et al. (2019) Student creativity in problem solving can be seen in the answers given by students as solutions to the problems given based on indicators of fluency, flexibility and novelty. Students who are able to provide

Refni Adesia Pradiarti
*Email: rapradiarti@gmail.com

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creative problem solving results through creative thinking processes (Leikin & Pitta-Pantazi, 2013).

Creativity can be described as a process (Görlich, 2023). The creative process based on Wallas' theory is divided into 4 stages, namely preparation, incubation, illumination, and verification (Haavold & Sriraman, 2022; Schindler & Lilienthal, 2020; Leikin & Sriraman, 2022). Haavold & Sriraman (2022) explained that the preparation stage consists of understanding the problems faced. The incubation stage occurs when a problem is put aside for a certain period of time. The illumination stage is when a solution suddenly appears while the individual may be engaged in another unrelated activity. At the verification stage, which includes expressing the results in language or writing. At this stage one verifies the results, makes them precise, and looks for possible extensions through the use of the results. Creativity in this perspective is a long-term process (Schindler & Lilienthal, 2020).

One way to evaluate student creativity is by giving questions that can be done in several ways such as Multiple Solution Tasks (MSTs) (Bicer, 2021; Leikin & Elgrably, 2022). MST is a math problem that can be solved in different ways (Bicer & Bicer, 2022; Leikin & Kloss, 2009). Students are invited to solve MST in various ways, based on the theoretical assumption that "solving mathematical problems in various ways is closely related to personal mathematical creativity" (Schindler & Lilienthal, 2022). Multiple solution task is a type of mathematical modeling with a creative approach (Lu & Kaiser, 2022). Schindler & Lilienthal (2022) consider that the ability to generate solutions in several different ways may reflect personal mathematical creativity.

Among various fields of mathematics, geometry is a topic that is difficult for students to understand (Evidiasari et al, 2019). In addition, geometry is considered a challenging subject in mathematics learning in secondary schools (Suryanti et al, 2023). Based on previous research by Mas'udah et al (2021) stated that geometry involves many complex aspects, making it difficult for some students to understand. Geometry topics offer visual mathematical objects that students can use to demonstrate their mathematical creativity through the application of some representation or visualization of mathematical objects (Bicer, 2021). Gridos & Avgerinos (2022) stated that geometry material allows for integration of various approaches to one problem, therefore geometry material can be packaged into multiple solution task questions. Based on initial observations at SMAN 3 Malang, students had difficulty solving MST questions in a variety of different ways that required students to think creatively.

Based on preliminary studies, there are students who have not been able to achieve any aspect of creative thinking, there are those who fulfill one aspect of creative thinking, and there are also those who fulfill all aspects of creative thinking so that there are differences in the level of creative thinking ability. Based on different students' creative thinking abilities, there are creative thinking processes that are skipped at certain levels of creative thinking, such as skipping the verification stage. Apart from that, there are also students who spend longer in one stage, namely the incubation stage, so it is necessary to explore further how students' creative thinking processes in completing multiple solution tasks on geometry material are based on their level of creative thinking.

Research related to the creative thinking process and its phases in completing MST was carried out by Schindler & Lilienthal (2020) where he found that students' creative thinking process consists of (1) Looking for a start, (2) Idea/intuition, (3) Working further,

step by step, and (4) Finding a solution/discarding the approach. The research shows that students working on MST develop different intuitions and have illumination which is a core element of the creative process. The researcher stated that the subjects in the study were active in learning mathematics, so it is necessary to explore further the creative thinking processes of other students with different mathematical competencies because there is a possibility that the "characteristics of the creative process" are not "the same for different individuals." (Haavold & Birkeland, 2017).

Based on the background above, it is necessary to conduct research to further analyze the creative thinking process of students in completing multiple solution tasks on geometry material based on their level of creative thinking. This research will analyze the strategies and approaches used by students in finding various solutions and explore the obstacles they may face during the problem solving process. It is hoped that the results of this research can contribute to the development of more effective mathematics learning and help improve students' creative thinking abilities in the context of geometry, especially in learning flat geometry.

▪ METHOD

Participants

This research was conducted at SMAN 3 Malang and the research participants were 32 students from class XI-D. The research subjects were 5 students with levels 0-4 who had been grouped after completing the Creative Thinking Ability Test. The research was conducted in August-December 2023. Subjects whose creative thinking processes were explored were selected after observing the characteristics of data found in the field. The criteria for selecting research subjects are: 1) fulfill the creative aspects of fluency, flexibility, and originality with the classification of Creative Thinking Ability Levels adapted from Siswono (2010) according to Table 1 and Table 2; 2) can complete multiple solution task questions to examine their creative thinking processes that preparation, incubation, illumination and verification according to Table 3; 3) can communicate well.

Research Design and Procedure

This research uses a qualitative descriptive research design aimed at describing students' creative thinking processes in completing multiple solution tasks. Researchers examined the stages of the creative process of students with different levels of creative thinking in completing multiple solution tasks based on the creative process theory by Wallas (1926) based on the level of creative thinking by Siswono (2010). Data collection was carried out twice, at the first meeting the researcher gave a Creative Thinking Ability Level test which would be used to group the subjects to be selected. In the second meeting, researchers provided questions that were used as an instrument to see students' creative processes where the subjects studied worked on multiple solution task questions and the work was recorded using a video camera to detect the creative process while working on the questions. After that, the researcher conducted interviews to obtain more detailed information about the students' creative process in solving multiple solution task questions along with the reasons why students took the steps used to solve the problems.

Instruments

The instruments used were 2 test instruments and an interview guide instrument. The first instrument is a test to determine the level of students' creative thinking abilities

developed by Siswono (2010), namely not creative (level 0), less creative (level 1), quite creative (level 2), creative (level 3), and very creative (level 4). The indicators of creative thinking ability used in this research are fluency, flexibility, and originality which are described in Table 1.

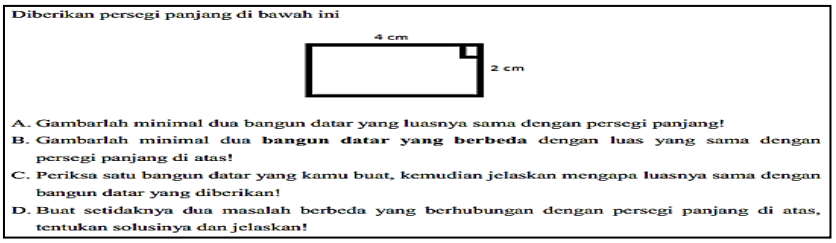

Figure 1. Creative thinking ability level test

Table 1. Indicators of creative thinking ability

Aspects of Creative Thinking	Indicator
Fluency	Students are able to provide as many relevant ideas or answers as possible correctly.
Flexibility	Students are able to provide many ideas or answers using various approaches/solving methods correctly.
Originality/ Novelty	Students are able to provide ideas or answers that are unique and unusual to those carried out by students at their stage of development or level of knowledge.

Table 2. Guidelines for grouping creative thinking ability levels based on indicator achievement

Creative Thinking Ability Level	Indicators of Creative Thinking Ability		
	Fluency	**Flexibility**	**Originality**
Level 0 (not creative)	-	-	-
Level 1 (less creative)	√	-	-
Level 2 (quite creative)	-	√	-
	-	-	√
Level 3 (creative)	√	√	-
	√	-	√
Level 4 (very creative)	√	√	√

The second instrument, namely the Multiple Solution Task, will be used as an instrument to see students' creative processes based on the stages of creative thinking by Wallas (1926) which consists of 4 stages, namely preparation, incubation, illumination and verification according to with Table 3. The instrument used is a modification of the research instrument by Schindler & Lilienthal (2020). Modifications are made because there are more steps that must be taken in finding the size of ∠BFC than finding the size of ε in the problem that is used as the source.

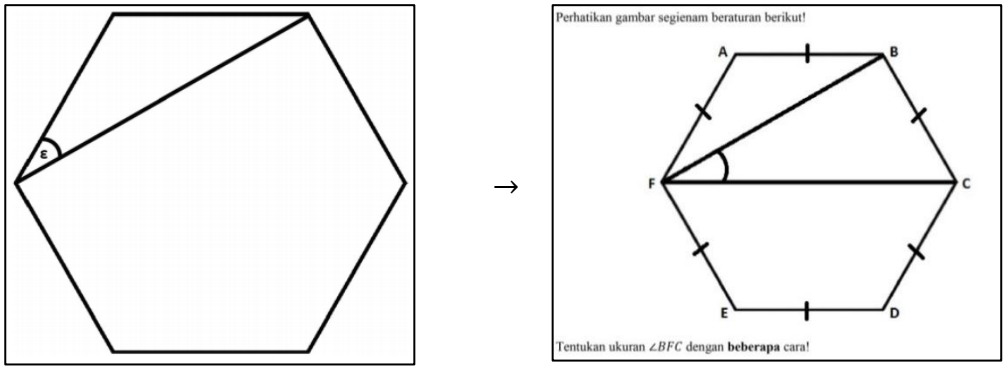

Figure 2. Modification of the multiple solution task used from the research instrument by Schindler & Lilienthal (2020)

Table 3. Conceptual framework of creative thinking process

No	Creative Thinking Process	Indicator
1	Preparation	• Write or mention information or data from the Multiple Solution Task questions given. • Make a solution plan in the form of: writing down or mentioning ideas or strategies that can be used in solving Multiple Solution Task questions, choosing an appropriate strategy or method for solving Multiple Solution Task questions.
2	Incubation	• Take up other activities that are not related to problem solving. • Look for ideas that will be used to solve the problem. • Choose certain ideas to solve Multiple Solution Task problems.
3	Illumination	• Choose the right idea or method. • Try to solve the problem using the selected idea. • Use the same idea to find another answer. • Use other ideas to find the same answer.
4	Verification	• Correct incorrect answers. • Recheck the repairs made.

Furthermore, an interview guide instrument was created by the researcher to further explore the students' creative thinking process in completing the MST in order to obtain more detailed information regarding the reasons for taking the completion steps as an explanation of the students' problem-solving data and video transcripts. Before being used in the field, all instruments were validated first by a mathematics education lecturer at the State University of Malang. The type of validation chosen by researchers is expert validation based on suitability of language, suitability to research objectives and suitability of construction.

Data Analysis

This research data analysis uses qualitative data analysis techniques which consist of 6 stages, namely (1) preparing and organizing data, (2) exploring and coding data, (3) describing data, (4) presenting and reporting findings, (5) interpreting research findings, and (6) validating the accuracy of the findings (Creswell, 2013). Researchers grouped

students based on their level of creative thinking ability, then took 1 subject from each group to describe their creative thinking process, then conducted interviews to further explore students' creative thinking processes at each level. The triangulation used is a triangulation method carried out by comparing data obtained from test results and interview results (Creswell, 2013).

▪ RESULT AND DISSCUSSION

Researchers determine research subjects based on the level of creative thinking that has been obtained based on the Creative Thinking Ability Test given. The choice of subjects is the result of considerations with the study field teacher, namely students who fulfill the aspects of creative thinking, are able to communicate well verbally and are students who are active in learning. There were 5 subjects studied further, namely 1 level 4 student (very creative), 1 level 3 student (creative), 1 level 2 student (quite creative), 1 level 1 student (less creative), and 1 level 0 student (not creative).

The research data was obtained from the results of creative thinking level tests, multiple solution task tests on geometry material and the results of interviews with research subjects. To obtain valid data, the social work process lasted 30 minutes and the interview process was documented by recording the interview process between the researcher and the subject. The results of the interview are written in the form of an interview transcript, thereby reducing missed data.

Description of the Subject's Creative Thinking Process with Creative Thinking Level 4

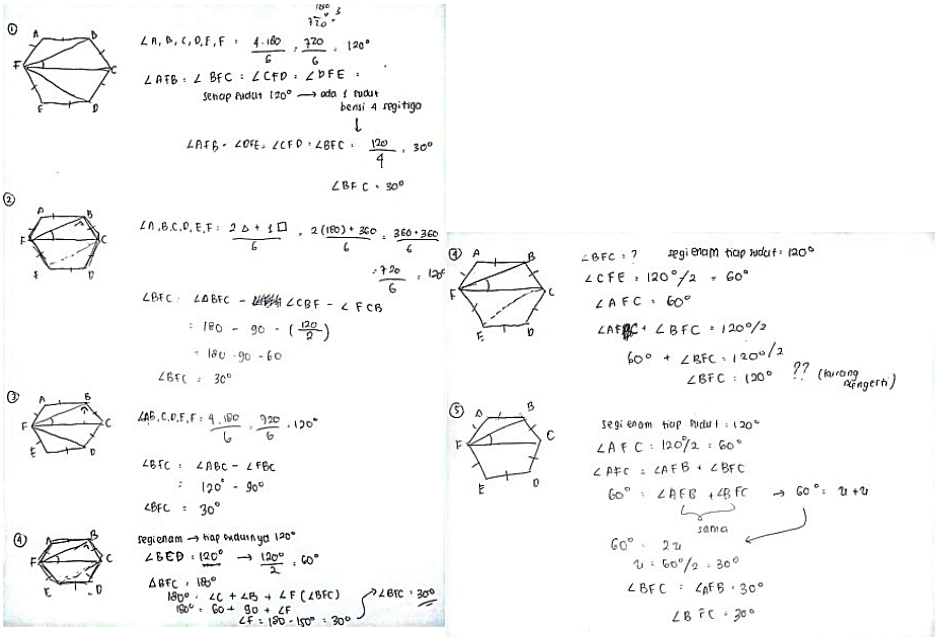

Figure 3. LV4 Subject Answers in Completing MST

The creative thinking process in subjects with level 4 thinking level, namely students who are able to meet the indicators of fluency, flexibility, and originality, is carried out through the stages of complete creative thinking, namely at the preparation,

incubation, illumination, and verification stages. Subjects were able to complete multiple solution tasks on geometry material in 5 correct ways and in full accordance with the stages of creative thinking. This is in accordance with the results of previous research by Schindler & Lilienthal (2020) which states that students with a good understanding and interest in mathematics will carry out a complete creative thinking stage, namely preparation which consists of activities to understand the problem they are facing and can be carried out in activities looking for symmetry and developing the information contained in the problem, then at the incubation stage, namely the problem is put aside for a certain period of time with silence for a moment before entering the illumination stage, at the illumination stage where students get ideas or intuition about how a problem can be solved and after having intuition about how to approach the problem, this phase includes reasoning to find solutions to problems that require steps specific reasoning with 3 stages in it, namely by looking for another approach, looking for errors in the previous approach, or eliminating the approach accompanied by a verification stage, namely by re-examining the approach given and recalculating the answers previously obtained.

At the preparation stage, the subject carries out by reading the question repeatedly and for each method/approach given, the subject first writes down how to get the size of each angle by making guide lines and so on based on the information contained in the question, namely a regular hexagon by finding every corner is big. This is in line with opinion Mashitoh et al. (2019) where students carry out preparatory activities by reading the questions to look for relevant information to solve the questions contained in the questions. For example, students with creative thinking level 4 use the information obtained in the problem in the form of a regular hexagon by finding the number of angles in the hexagon using different approaches and different guide lines, some use a combination of 4 triangles or a combination of 2 triangles and 1 quadrilateral. .

The incubation stage is carried out by the subject in silence and does not take a long time, where the incubation time by the subject is not used to carry out other activities outside of working on questions other than being quiet to think for a moment. This is in accordance with the explanation Schindler & Lilienthal (2022) that in working on MST, the creative thinking process will be shorter for students because the processing time is much shorter, so it may affect the incubation and nature of the illumination or emergence of ideas. Next, in the illumination stage, ideas begin to emerge and students work on multiple solution tasks in 5 different ways, where students with creative thinking level 4 or very creative get 5 correct solutions even though there are several ways that are similar to the method that has been done, such as in method 1 with 5 and 2 with 4 and students get ideas for doing it also based on previous experience. This is in line with research by Alimuddin et al. (2019) which states that students who meet all the creative thinking indicators provide answers that depend on their experience of problems that are similar to the problems faced in decision making.

At the verification stage, the subject is carried out by re-checking the answers given in each method after completing the 6 approaches given, although there are still several things that have been missed so that there are still incomplete answers but have been confirmed through interviews, this is in line with Hines et al. (2019) where the verification stage involves testing new ideas generated by the individual.

Description of the Creative Thinking Process Subject with Creative Thinking Level 3. Figure 4 shows the answers of subject LV3 in completing the MST:

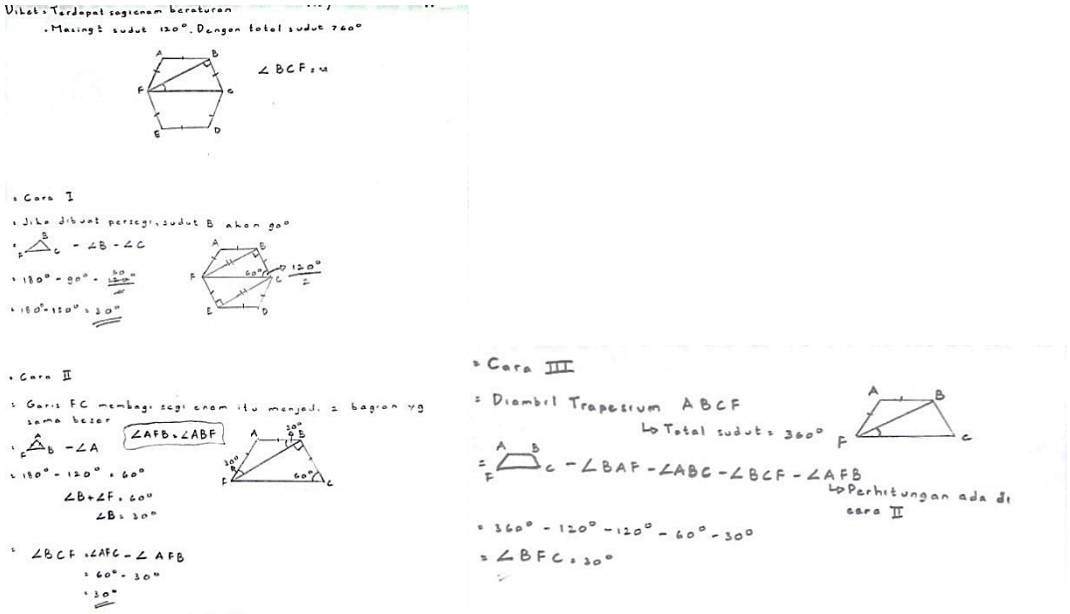

Figure 4. Answers to Subject LV3 in Completing MST

Based on the results of working on multiple solution tasks on geometry material by subjects with creative thinking level 3 (creative) who were able to meet the fluency and flexibility indicators, the creative thinking process was carried out through the creative thinking stages of preparation, incubation, illumination and verification. Subjects were able to complete multiple solution tasks on geometry material in 3 correct ways and in full accordance with the stages of creative thinking. This is in line with Siswono (2007) where level 3 students are able to produce new ideas that are original and useful to solve problems or situations faced with the creative thinking process of students with level 3 creative thinking including preparation, incubation, illumination, and verification.

At the preparation stage, the subject carries out this by reading and understanding the questions repeatedly as well as writing down information that is known, asked about, as well as information regarding the steps the student will take in working on the questions, including writing the angle sizes in a regular hexagon even though there are errors in writing the number of interior angles. This is in line with Aries et al (2018) namely level 3 students carry out the preparation stage by understanding the problem or situation they are facing well and gathering relevant information, identifying the problem or situation they are facing and determining the goals they want to achieve, considering various possible solutions and strategies that can be used to achieve these goals, and using previous knowledge and experience to help solve the problem or situation at hand.

The incubation stage by level 3 subjects is carried out in silence for a moment and does not take as long as level 4 students, where the subject's incubation time is not used to carry out other activities outside of working on questions other than being quiet to think for a moment. This is in accordance with Schindler & Lilienthal (2020) in completing MST, students do not engage in phases where they postpone problems and think about other things instead. These differences are due to the nature of the problem to be solved

and the given environmental situation. While some complex, open-ended mathematical problems are worked on over a longer period of time, the goal in MST is to solve them in a variety of ways in a relatively short time.

At the illumination stage, level 3 students work on the multiple solution task in 3 ways. Students work on questions using 3 different approaches, focusing on triangle BFC, then methods 2 and 3 focus on trapezoid ABCF. Level 3 students use various different approaches where their ideas are based on developing their initial knowledge regarding the size of each angle of a hexagon, then calculating the angle size of the shape that is in focus, this shows that these students develop the ideas obtained after the incubation stage in line with Sari (2016) While experiencing the illumination stage, students develop ideas that come to mind to solve problems by linking their ideas to mathematical concepts related to the problem.

Next, at the verification stage, the subject carries out the verification stage on the 3 approaches given by re-checking the answers that have been written every time he completes each method, which means he completes one method and then checks again before moving on to other methods and approaches. This is in line with Bicer & Bicer (2022) where students verify in various ways, such as checking their answers again, matching the solution with the method they used previously, or looking for errors in previous approaches and correcting them.

Description of the Subject's Creative Thinking Process with Creative Thinking Level 2. Figure 5 shows the answers of subject LV2 in completing the MST:

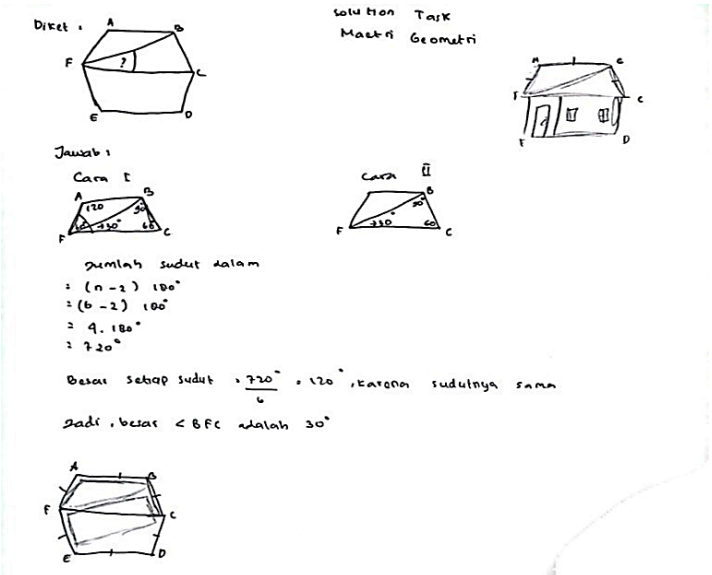

Figure 5. Answers to Subject LV2 in Completing MST

The creative thinking process of students with level 2 creative thinking level is creative enough to be able to meet the flexibility indicators only where they carry out all stages of the creative thinking process, namely preparation, incubation, illumination, and verification. Based on the results of the answers given, level 2 students are able to complete the multiple solution task in 2 ways. Level 2 students carry out the preparation stage by reading and understanding the questions and drawing pieces of hexagons which

are the focus for finding the size of ∠BFC. Apart from that, level 2 students use the information in the questions in the form of regular hexagons by finding the angles in the hexagon using formulas they have studied previously. This is in line with Putri & Pratama (2019) one of the indicators in the preparation stage is collecting information to solve problems by remembering the lessons that have been taught here in the form of remembering and using formulas that have been studied to find out the size of the angles in the hexagon. . Next, at the incubation stage, carry out other activities that are not related to working on the questions by being silent and thinking for a long period of time and drawing another shape that is shaped like a house. Level 3 subjects carried out the incubation stage for quite a long time, this is in accordance with research by Sari (2016) where students who are creative enough stop thinking about solving problems when they experience difficulty in solving problems and carry out activities that are not related to solving problems and while doing other activities the subject does not think about problems.

At the illumination stage, level 3 subjects wrote quite detailed answers with 2 different approaches in each method presented. The approaches given are related to each other because method 1 is used to determine the size of ∠FBC. At this stage, level 2 students have not written down in detail the solutions they have made but can explain in detail during interviews, this was also conveyed Muzaki et al (2022) namely at the illumination stage students can convey several ideas that will be used as solutions and can show his ideas to get the right answer. At the verification stage, level 2 students carry out the verification stage by re-reading the answers given, although contrary to the research results of Melyana et al (2022). students who are able to meet the flexibility indicators do not carry out verification in their creative thinking processes.

Description of the Subject's Creative Thinking Process with Creative Thinking Level 1. Figure 6 shows the answers of subject LV1 in completing the MST:

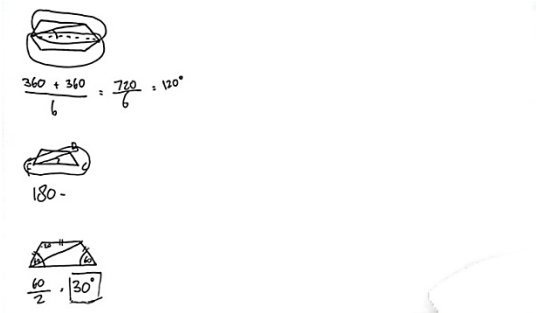

Figure 6. Answers to Subject LV1 in Completing MST

Based on the results of working on multiple solution tasks by subjects with creative thinking level 1 (less creative) who were only able to meet fluency indicators, the creative thinking process was carried out through the creative thinking stages of preparation, incubation, and illumination. The subject is able to complete multiple solution tasks on geometry material in 1 correct way and has not yet fully fulfilled the stages of creative thinking. At the preparation stage, this is done by reading and understanding the questions and drawing a piece of the hexagonal shape that is the focus to find the size of ∠BFC and circling the part that will be used. Level 1 subjects divide the hexagon into two trapezoids

so that they use a combination of two trapezoids to find the number of angles in the hexagon and the size of each angle in the hexagon so that level 3 students have entered the preparation stage because they are able to understand and use the information contained in the questions well (Muzaki et al, 2022).

At the incubation stage, the subject takes on other activities that are not related to working on the questions by remaining silent and thinking for a long period of time until he can continue solving the questions even though he has not been able to solve the problem in method 1 properly. Next, at the illumination stage, level 1 students have not written detailed answers, but when they are interviewed, they are able to communicate the answers given. Furthermore, at the verification stage, level 1 students have not checked their answers again because they have re-entered the incubation stage and remain silent until the time for working on the questions ends. This is in line with the research of Machromah et al. (2015) where students who are less creative will stop and observe the picture when they reach a dead end in solving a problem.

Description of the Subject's Creative Thinking Process with Creative Thinking Level 0.

Subject LV0 only received 1 incomplete method in solving the multiple solution task given in the geometry material. Figure 7 shows the answers of subject LV0 on MST on geometry material:

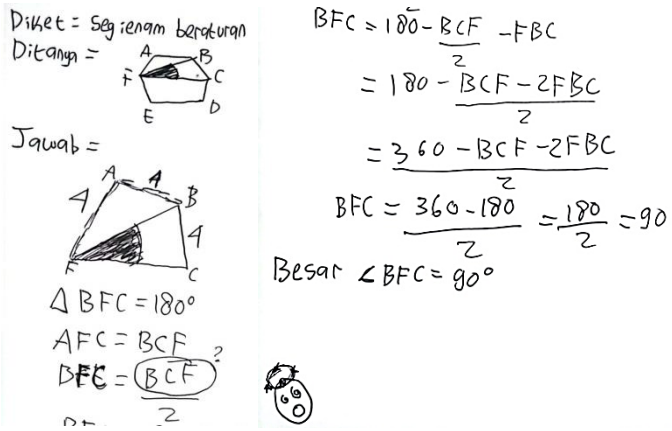

Figure 7. LV0 Subject Answers in Completing MST

The creative thinking process of students with creative thinking level 0 is not creative and has not been able to meet the creative thinking indicators to fulfill the preparation, incubation and illumination stages. Based on the results of the answers given, level 0 students were able to complete the multiple solution task in 1 way but it was not correct. Level 0 students carry out the preparation stage by reading the question and rewriting the information known in the question and redrawing the hexagon shape while shading the part of the size of ∠BFC that is being asked. Level 0 students cannot use the information they know in the problem well because they do not use regular hexagon instructions to find the size of each angle in the hexagon. This happens because students with level 0 creative thinking at the preparation stage experience difficulty in

understanding the problems or situations they face and gathering relevant information (Prianggono, 2013).

At the incubation stage, level 0 students take other activities that are not related to working on questions by being silent and thinking for a long period of time and drawing other shapes that are shaped like a person who is confused. The incubation stage carried out by level 0 students is carried out so that they become more focused while calculating the written answers, this is in line with Bicer & Bicer (2022) where students carry out the incubation stage by carrying out activities such as drawing, holding their hands together and touching their chin, as well as other activities that can help restore students' concentration and focus.

At the illumination stage, students wrote only 1 alternative answer but did not get the correct final result. Subjects focused on the trapezoid ABFC and did not look for the measure of each angle in the given hexagon. Subject LV0 focuses on the triangle BFC with the sum of the interior angles being 180°, then looks for the size $\angle BFC = 180 - \angle\frac{BCF}{2} - \angle FBC$ to get the final result, that 90°, where the calculation will be complicated because the subject does not yet know the size of ∠BCF which should be known through calculating angles in a hexagon. Level 0 students have not yet carried out the verification stage, that is, they have not checked the answers given again, so they only realize that the answers given are wrong during the interview process. Level 0 subjects have not fulfilled all stages in the creative thinking process and require a long time at the incubation stage, this is in line with Mashitoh et al. (2019) students with a low level of creative thinking need quite a long time to come up with an idea, after the question has been read several times and understood, sometimes they still don't get an idea for a solution. Apart from that, after finishing working on the subject question, they feel that the answer written is correct so they don't check again every time. the steps.

▪ CONCLUSION

Based on the research results, there are differences in students' thinking processes in completing Multiple Solution Task. At the preparation stage, each subject is able to understand the information given in the question and apply it to each method/approach given, the subject first writes down how to get the size of each angle by making guide lines and so on based on the information contained in the question, namely hexagons. orderly. In the incubation stage, level 4 and 3 subjects take part in activities outside of working on questions in silence and do not take long, while level 2, 1 and 0 subjects take a long time in the incubation stage. The difference in the stages that each subject goes through at this stage is that level 2 and 0 subjects carry out other activities besides being silent, namely drawing something outside the problem with the aim of feeling more focused.

In the illumination stage, level 4 subjects do MST in 6 different ways, level 3 subjects do MST in 3 different ways, level 3 subjects do MST in 2 different ways, level 3 subjects do MST in 1 way, and level 0 subjects do MST in 1 method but it's not quite right. At the verification stage, subjects at levels 4, 3, and 2 recheck the answers given even though there are still several things that are missed so that there are still incomplete answers. The verification stage has not been carried out by subjects with levels 1 and 0 because subjects with a low level of creative thinking usually feel that the answers given are correct so they have not re-checked the answers given. Based on research findings, it

is recommended that teachers familiarize students with carrying out the checking stage again and provide MST questions based on problems packaged in story questions so that students get used to working on story problems with many solutions.

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