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Student creative thinking process in solving geometry problems based on van hiele level

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Abstract. The purpose of this study is to describe the students' process of creative thinking in solving geometry problems based on the level of Van Hiele in class VII-E SMP Negeri 1 Jember. This research is a descriptive research with qualitative approach. Data collection methods used were tests and interviews. In this study, data analysis was conducted using descriptive analysis. Data analyzed in this research is students' answer sheet on problem solving test about creative thinking process and result of interview. The results of the analysis show that each subject differs in the creative thinking process. Creative thinking process at the stage of preparation according to Van Hiele level but at the incubation stage, illumination stage, and verification stage does not match the level of Van Hiele. So, not all students who is at a high level in Van Hiele Level, their creative thinking process is also high and vice versa. This is due to different students' experiences in solving problems and concentration levels of students.

1. Introduction

High-order thinking is an important component of 21st century skills [1]. It is an ability of thinking critically, creatively, the ability of arguing, discussing, making decision and solving problems [1], [2]. One of the capabilities needed to respond to the challenges of today's global era is the ability to think. The ability to think is one of the students' abilities developed in school. Most people are assumed to be creative, but the degree of creativity is different [3]. This can be demonstrated by the evidence of the extraordinary creation of certain people in technology and knowledge, let's say Thomas Alfa Edison, Newton or Einstein. On the other hand there are people who cannot be creative but only awear or have no knowledge or skills at all. This state indicates the different level or degree of creativity or creative ability of someone. There are some indicators to assess students' creative thinking (fluency, flexibility and novelty) using problem filling and problem solving. Meanwhile, the process of creative thinking is a real picture in explaining how creativity occurs. In creative thinking, the process that occurs turn out to go through several specific stages [4].

The process of creative thinking can be seen from the perspective of Wallas theory. Wallas in his book "The Art of Thought" states that the creative process includes 4 stages, namely: preparation (gathering relevant information), incubation (resting for settling problems and information obtained), Illumination (inspiration), Verification (testing and judging ideas acquired) [5]. The National Council of Teachers of Mathematics (NCTM) puts problem solving in the first place of the central goal of mathematics education, in a paper entitled Essential Mathematics for the 21st Century. Posamentier and Stepelmen [6], The National Council of Supervisors of Mathematics (NCSM) put problem solving as the first sequence of the 12 essential mathematical components. Meanwhile, in the Trends in International Mathematics and Science Study (TIMSS) 2007 report, Indonesian students are in position 36 out of 49 countries surveyed. Indonesia's achievements are far below other Asian countries. With an average of 500 international scores and 100 deviation standards, Indonesia's math score is at 397. Thus, the value of Indonesian mathematics is significantly below the international average. On the one hand math problem solving is important, but on the other hand students often have difficulties in solving math problems [7]. "Other weaknesses found are the weakness of students in analyzing problems, monitoring the completion process, and evaluating the results, which are less visible in students." In other words, students do not prioritize the problem solving technique but rather prioritize the end result.

Geometry is closely related to a problem in everyday life, one of which is problem with two-dimentional figure. Van de Walle reveals "Five reasons why geometry is so important to learn. First, geometry helps humans have a complete apperception of their world. Geometry can be found from the solar system, geologic formations, crystals, plants, stars to architectural artwork and machine work. Second, geometric exploration can help them to develop everyday problem solving skills. Third, geometry plays a leading role in other mathematical fields. Fourth, geometry is used by many people in everyday life. Fifth, geometry is full of challenges and interesting."[8] However, the students' ability in understanding the material of geometry is so low that students are less able to solve geometry problems. Sunardi's research states that "there are still many junior high school students who have not understood the concepts of geometry. Of the 443 junior third graders, 86.91% stated that the square is not a rectangle, 64.33% states that the rhomb is not a parallelogram, and 36.34% states that on the square, the two opposite sides are perpendicular to each other" [9]. In conveying a learning material, the teacher should pay attention to the level of students' ability. The teacher must know the level of students' mental development and how the teaching should be done to fit the levels of the development. Suherman states that "learning that does not pay attention to the level of students' mental development is likely to result in students experiencing difficulties because what is presented to students is not in accordance with the ability of students to absorb the material given [10].

Epoh points out that "the Van Hiele Theory states that the students' geometrical thinking level sequentially through 5 levels, Level 0 (visualization), Level 1 (analysis), Level 2 (abstraction), Level 3 (deduction) , and Level 4 (rigor)" [11]. Students who are supported with appropriate teaching experience will pass through these five levels, where students cannot reach a level of thought without passing the previous one. Each level demonstrates the thinking ability that someone uses in learning the concept of geometry. The basis of classification in this study uses the Van Hiele theory in compiling geometric questions. Van Hiele's theory focuses on geometric material, examines the levels of understanding in geometry learning, explains the general description at each level described in a more operational description, has accuracy for describing the level of students' thinking in geometry. Therefore based on the previous description, a study was conducted with the title "students' Creative Thinking Process in Solving Geometry Problems Based on Van Hiele Level".

This research is different from previous research, research Aisia U. Sofyana, Mega T. Budiarto discuss about Profile of Geometry Skills of Junior High School Students in Solving Geometry Problems Based on Developmental Levels of Van Hiele Thinking [12]. Research Ahmad Syafi'i discuss about Identifying Student Thinking Levels Based on Van Hiele Theory in Solving Geometry Problems [13]. Research done by Saleh Haji about Improving Problem Solving Ability Through a Realistic Mathematical Approach [14]. This research focuses on the profile of geometric skills, students' level of thinking and geometry problem solving

2. Methodology

The type of this research is descriptive research with qualitative approach. There are three students selected as research subjects, each from the level of visualization, level of analysis, and level of informal deduction in class VII-E SMPN 1 Jember. In this study, the researcher acts as a research manager as well as the main instrument in collecting data. Supporting instruments are Van Hiele

Geometry Test, creative problem solving test, and interview guide. The experiment was conducted by giving the first test of Van Hiele Geometry Test to all students in one class who is familiar to the Van Hiele level. Next, each student from each level Van Hiele was determined as the research subject. After giving the first test, the next step was to give a second test which was a creative problem-solving test to three specified students.

Van Hiele Geometry Test, creative problem solving test, and interview guide had been validated by 2 S1 lecturers of Mathematics Education University of Jember and one S1 lecturer of Tadris Mathematics Department STAIN Jember. The final step was an interview which aimed at ensuring the student's writing and reinforcing the findings obtained, as well as for obtaining a more in-depth analysis. The problems given to the research subjects are as follows:

Mr. Lukman has a trapezoidal land. The size of the trapezoid parallel sides was 25 m and 15 m. The distance of two parallel sides was 10 m. The land was devided into two equal plots. Each plot was planted with watermelons and melons. Mr. Lukman wanted to devide the two plots of land with a fence.

a. **Describe the position of the fence so that you can devide the land into two equal plots?**
b. **How long is the fence that Mr. Lukman needs?**

Figure 1. Creative problem solving test

Data analysis was done by transcribing the collected verbal data, examining all available data, data reduction, data exposure, and drawing conclusion. This data analysis is the main objective of the study, aiming to describe the creative thinking process of students based on the level of visualization, level of analyst, and the level of informal deduction at Van Hiele Level relating to the characteristics of fluency, flexibility and novelty. Analysis of creative thinking process is done per stage by using the stages of the Wallas, namely: preparation stage, incubation stage, illumination stage and verification stage.

3. Results And Discussion

The results obtained from the first test of Van Hiele Geometry Test given to 31 students in class VII-E are presented in the following pie chart.

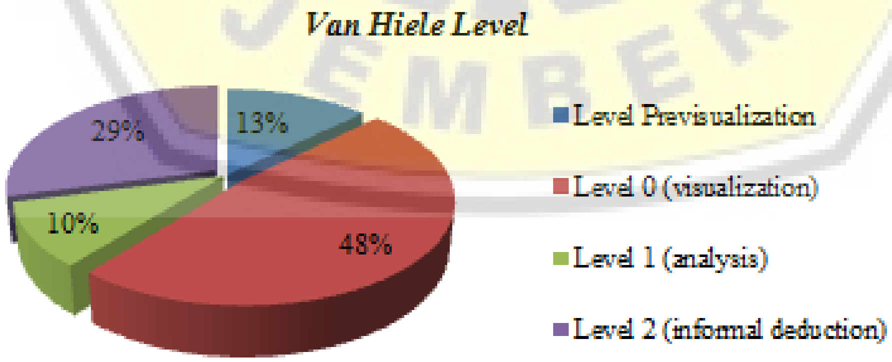

Figure 2. Van Hiele Level Student Class VII-E

After the first test of Van Hiele Level classification, 1 student was selected from each Van Hiele Level. The students came from one person at Level 0 (visualization), one person at level 1 (analysis), and one person at level 2 (informal deduction). The chosen subjects solved the second test problem that was the problem solving test of creative thinking of geometry material which was then analyzed their creative thinking process based on the result of written work and interview. The following is a description of the creative thinking process of students with the level of visualization, level of analysis, and level of informal deduction in solving problems given in accordance with the stages of Wallas. Creative Thinking Process of Student of Informal Deduction Level (S1) in Solving Geometry Problems

Based on the research findings, each subject which was S1 (Student of Informal Deduction Level), S2 (Student of Level Analysis), and S3 (Student of Level Visualization) could complete the problem-solving test according to the stage of creative thinking process (Wallas stage) which was determined beforehand. The analysis results showed that each subject was different in the process of doing the problem solving.

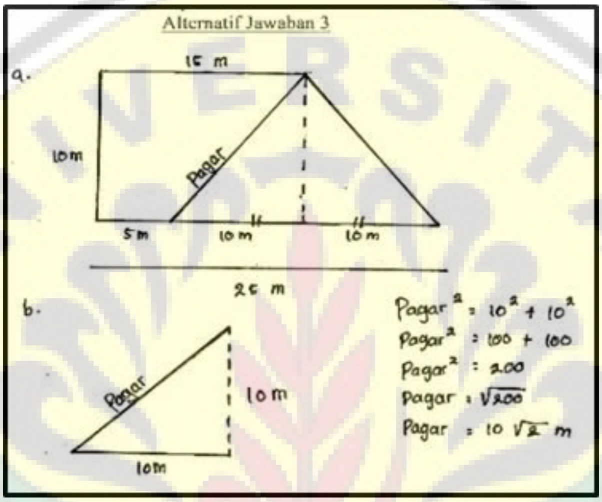

Figure 3. Answer footage from S1 Subject
(Student of Informal Deduction Level)

In the preparatory stage, the results of interviews with students related to the preparation phase showed that S1 was quite clear with the given problem. This could be seen when S1 answered that the sentence on the matter was quite clear. When asked about the purpose of the question, S1 answered the question fluently. This was seen from when S1 wrote down the problem variables the questions, he was able to write in a coherent manner. S1 could restate the problem of the given problem completely, correctly and smoothly. When asked about what was known and asked on the question, S1 answered the questions using his own language which could be seen when he was declaring trapezoidal with parallel sides of 25 m and 15 m. Distance of two parallel lines equals to 10 m which means the trapezoid height was 10 m. The students could determine the way to position the fence so that the land could be divided into two equal areas. During incubation stage, it could be said that S1 was able to think of the concept of answering the question smoothly by telling how the position of the fence to be divided into two trapezium with the same area. Although showing the inadequacy of S1 in solving the test questions, S1 was able to think about the concept. S1 was able to find 3 alternative fence positions to be divided into two with the same area. S1 was able to answer uniquely that when answering isosceles trapezoid he could think alternative answer if the trapezoid was a right-angled trapezoid. S1 explained how to find 3 alternative answers that was by trying to scribble the image.

At Illumination stage, S1 provided an explanation to get 3 alternative answers using isosceles trapezoid and right-angled trapezoid. When the trapezoid was an isosceles trapezoid, S1 easily divided it vertically straight in the middle to prove whether the width of each area was the same. On the second alternative, initially S1 had difficulties to divide because he drew the fence with the wrong slant. But, after S1 tried to fix and to divide the fence in a sloping position with the help of dashed lines on the trapezium height finally S1 could find the answer correctly. When S1 found the answer of the third alternative, S1 motivation was known from the interview when he mentioned the various types of trapezoid. S1 answered isosceles trapezoid then S1 tried to draw and to calculate and finally S1 was able to find the answer correctly even though it took a relatively long time. At Verification stage, S1 wrote and completed the questions in detail and coherent manner. In each step S1 always wrote the formula correctly, calculated carefully although it took a relatively long time because he had to dabble. The final result of S1 conclusion obtained 3 different alternative answers using 2 concepts of isosceles trapezoid and right-angled trapezoid. When S1 was asked to check whether the answer was correct, S1 replied confidently that the answer was correct.

Creative Thinking Process of Student of Analysis Level (S2) in Solving Geometry Problems

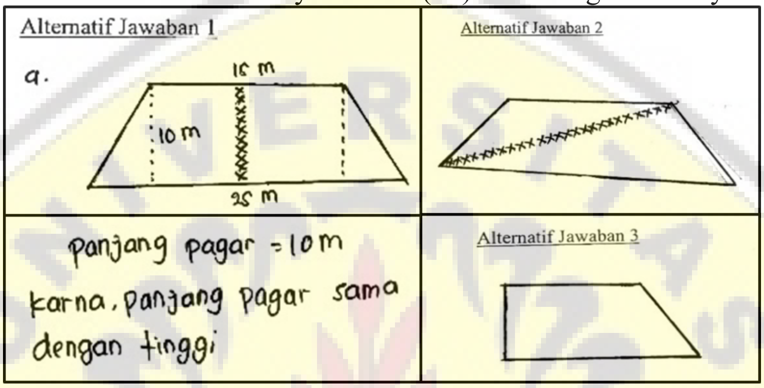

Figure 4. Answer footage from S2 Subject (Student of Analysis Level)

At the preparatory stage, S2 was quite clear with the given problem. It was shown when S2 answered the question smoothly. This was seen from when S2 wrote the variables of the questions. S2 was able to write in coherence. S2 can restate the question of the problem given correctly and smoothly. When asked about what was known and asked on the question, S2 replied using his own language which was seen from the declared trapezoidal with parallel sides of 25 m and 15 m. Distance of two parallel sides was 10 m which meant the height of the trapezium was 10 m. S2 could figure out how to position the fence so that the land could be divided into two equal areas. At Incubation stage, S2 when asked if he was used to meeting questions like this, S2 replied that he never encountered a problem like this before. However, S2 was able to think of the concept of answering the question smoothly. S2 knew the position of the fence which could divide the trapezoid into two isosceles trapezoid with the same area. S2 was also able to think of alternatives how to solve the problem if the trapezoid was a right-angled trapezoid but failed to find out how the position of the fence to be divided into two equal widths. S2 was only able to find 1 alternative answer related to the position of the fence to be divided into two with the same area. At Illumination stage, S2 gave explanation to get 1 alternative answer using isosceles trapezoid. S2 divided it vertically straight in the middle but did not write proof related to the extent of each area which was the same.

The second alternative, S2 was only able to draw the position of the slanted fence as in the picture above but did not find results for the length of the fence, because S2 had difficulties in calculating the length of the fence with the position without the help of dashed lines for the trapezoid height. At the third alternative answer, S2 was only able to draw a rightangled trapezoid but could not find the position of the fence in order to divide it into two equal parts. S2 looked rushed and did not concentrate when the researchers interviewed him. At Verification stage, S2 obtained 1 alternative answer using isosceles trapezoidal concept. When S2 was asked to check whether the answer was correct, S2 replied that the answer was correct and quickly surrendered not being able to give the second and third alternative answers. Creative Thinking Process of Student of Visualization Level (S3) in Solving Geometry Problems

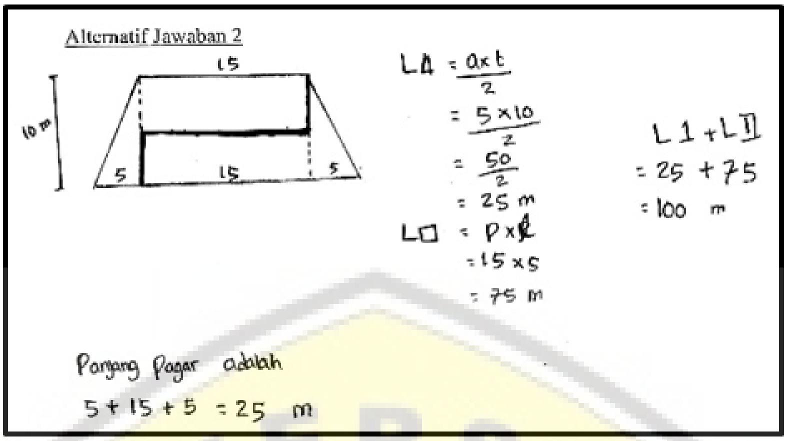

Figure 5. Answer footage from S3 Subject (Student of Visualization Level)

At Preparatory stage, S3 looked doubtful with the purpose of the question. He only showed correctly what was known and asked and rewrote it using the phrases from the question. Besides that, S3 did not show that the distance of the two parallel sides was the height of the trapezium, but when S3 was asked about the meaning of the problem S3 was able to explain the question asked which was about how the position and how long the fence for trapezoidal land was divided into two equal parts. At Incubation stage, S3 when asked if he was used to meeting questions like this, S3 answered that he never encountered such a problem before but not exactly like this. S3 was able to think of the concept of answering the question smoothly which was how the position of the fence could divide isosceles trapezoid into two equal area. S3 was also able to think of alternatives method to determine the trapezoid type but failed to divide it into two equal parts using the fence. So S3 was only able to find 2 alternative fence positions to divide the trapezoid into two with the same area. S3 was able to give unique answer when S3 divided the isosceles trapezoid into two with the meandering position of the fence.

At Illumination stage, S3 gave an explanation to get 2 alternative answers using isosceles trapezoid and right-angled trapezoid. If the trapezoid was isosceles, S3 divided it easily vertically straight in the middle but did not write proof related to the extent of each which was the same. This second alternative was unique, originally he drew an isosceles trapezoid with two right and left dashed lines on the trapezoid height. Then, S3 drew the position of the fence horizontally in the middle but the fence could not divide the trapezoid into two fields perfectly. This happened because there was a gap in both left and right. The researcher explained that if the fence must be intact from one side to the other side. So, S3 decided in order the fence to connect to the sides then he added the vertical line up and down like the picture above. Finally the isosceles trapezoid was divided into two with each merging between the triangle and rectangular. On the third alternative answer, S3 was only able to draw a right-angled trapezoid but could not find the position of the fence so that the trapezoid was divided into two equal parts. At Verification stage, the final result of S3 conclusion got 2 different alternative answers using isosceles trapezoidal concept. When S3 was asked to check whether the answer was correct, S3 was still trying to see the answered answer and correcting the answer. Right after that, S3 replied that the answer was correct. The results of this study are in harmony with Van Hiele's theory which says that the process of thinking development from level one to the next is not determined by age or biological maturity, but rather depends on the teaching of the teacher and the learning process the students have undergone. In addition, research conducted by Akkaya shows that there is a significant increase in the level of students' creative thinking after being taught using the Van Hiele model. [15]

4. Conclusion

Based on the results of data analysis and discussion, it could be concluded that each subject was different in the process of its creative thinking. Creative thinking process was based on Wallas theory includes 4 stages: preparation, incubation, illumination, and verification. At the preparatory stage on the Informal Deduction level, students were able to understand the problem and rewrote it using their own language correctly and fluently, as well as in the students of Analysis. Students of Visualization Level looked hesitant at first but finally could understand the problem. This could be seen when the students could not write it back using their own language but using the language as listed on the problem. At the incubation stage, the students of Informal Deduction level were capable of understanding the concept even though they had never encountered a problem like this before. Nevertheless, they were trying to find the answer by trial and error. This happened as well to the students of Visualization Level. The students of Analysis Level were able to understand the concept and had encountered such problem before although it was not exactly the same. At the illumination stage, there were different creative thinking processes between each level of Van Hiele.

The Informal Deduction Level was able to meet all the indicators of creative thinking. This was because it was able to answer 3 alternative answers correctly according to the characteristics of fluency, flexibility and novelty. Students of Level Analysis did not meet all the indicators of creative thinking. This was because they were able to answer 1 alternative answer correctly according to the characteristics of fluency only. Meanwhile, students of Visualization Level were not able to meet all the indicators of creative thinking. This was because they were able to answer 2 alternative answers correctly according to the characteristics of fluency, and novelty. At the verification stage, there was a difference of creative thinking process between each level of Van Hiele. The Informal Deduction Level was able to correct the answer again, as well as the students of Visualization Level. The students of Analysis Level immediately gave up and did not want to correct the answer again.

In conclusion, not all students who was in Level of Van Hiele has high level of creative thinking processes. Similarly, students at low levels in Van Hiele, not all of them were low in creative thinking processes. This was due to the differences in student experiences in solving problems and their concentration levels.

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