Students’ Creative Thinking Process in Solving Ill-Structured Problem at Eight Grade Students with High Ability

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Abstract. Creativity and problem solving are important skills in facing 21st century, but students’ creativity in solving mathematics problem is various. Therefore, to improve students’ creative thinking, teacher have to know their creative thinking process. The purpose of this research is to describe the students’ creative thinking process in solving ill-structured problem at high-ability students. The research type is descriptive with qualitative approach. The subjects of this study were two high-ability students. Result of the research showed that in the preparation stage, high-ability students understand the problem well and collected the datas and informations known from the problems. In the incubation stage, they were silent for a moment; reread the information obtained from preparation stage; made an illustration from the problem; and recalled ideas from their prior knowledge. In the illumination stage, high ability students found another idea by analyze the previous idea, planned the problem solving carefully; connected mathematic ideas to the reality; and continued solve the problems use the idea obtained from the previous stage. In the verification stage, high-ability students rechecked the calculation; verified the ideas; and revised the invalid ideas.

1. Introduction
Learning activities at school is expected to prepare students to face more challenges in the future life. Therefore, learning activities nowadays move to 21st century learning that refer to four characters known as 4C, critical thinking and problem solving, creative and innovation, collaboration, and communication. Problem solving and creative thinking are important skills in 21st century learning. Problem solving is a process to answer questions using student’s understanding, skills, and prior knowledge.

Creative thinking might be defined as a combination of logical thinking and divergent thinking which is based on intuition but has a conscious aim [1]. Problem solving is also an indispensable skill in mathematics. In solving mathematical problems, creative thinking in mathematics is often required. Creative thinking skill is needed to prepare students to face various problems in mathematics. Students can understand the problems quickly and obtain ideas to solve the problems. Student’s creative thinking is needed to raise, describe, and arrange ideas in solving mathematics problems.

Guilford stated that problem solving and creative thinking were closely related [2]. Krutetskii said that creative thinking in mathematics can be seen in finding ways and means to solve problems and finding original methods of solving nonstandard problems, it means that creative thinking skills are intended to be used in solving mathematical problems in school learning [3].

Creative thinking occurs through several stages. To determine the students’ creative thinking process, the creative process developed by Wallas can be used. Wallas’ creative thinking process is one of the most common theories used to determine creative thinking processes. Therefore, this study was used
Wallas’ creative thinking process. According to Wallas, there are 4 stages in creative thinking, preparation; incubation; illumination; and verification [4]. Preparation stage consists of focuses to explore and identify the problem [5] and approaching the subject matter and studying it to find an idea [6]. The incubation stage is the stage where students put the problem aside for a while [7]. Illumination stage is the stage when students comes up with inspiration and new ideas [7]. In illumination stage, students finding more than one problem-solving idea [8]. In verification stage students make sure that the problem solving is correct, they test and examine the problem solution [9].

Teachers need to know the students’ creative thinking process in solving mathematic problems to improve their creative thinking. Each student must have different background, skills, and learning achievement. It will affect the way they think so that it will cause differences in their creative thinking process. Students with different abilities will provide different creative thinking processes. This study will describe creative thinking process at high ability students.

There are various types of mathematical problems. According to Jonassen, mathematical problems are divided into two types, well-structured problem and ill-structured problem [10]. Well-structured problems are problems that have convergent solution and have well defined rules. Ill-structured problems are the opposite of well-structured problems, it has multiple solutions, solution paths, and the rules are not well defined. It can be defined as a problem which has vague goals and multiple solution paths [11]. Ill-structured problem has uncertain rules, unclear purpose, and has no limiting condition [12].

Hong & Kim defined 3 properties of ill-structured problems as authenticity, complexity, and openness [13]. A problem can be said to be authentic if it covers the context of everyday life and is quite relevant to deducing an integral part of the real-life situation [14]. Ill-structured problems are usually encountered in real life situation therefore the solution is unpredictable. Complexity means that ill-structured problems have incomplete rules or uncertainly organized. Openness means that students can build various interpretations and justify their own interpretations about the problem. Ill-structured problem is one of the problems that require students to use their creativity in mathematics to solve it. Ill-structured problem is not limited by the content learned in class, so the solution is unpredictable. The problem used in this research is ill-structured problem. The objective of this study is to describe the students’ creative thinking process in solving ill-structured problems at students with high-ability.

2. Research Method

The type of this study is qualitative descriptive research. The research was conducted to two students with high ability at eight grade, named S1 and S2. The subjects were selected by purposive sampling technique. In this study, think-aloud method and interview was used to collected data. Think-aloud method can accurately reflect conscious thought [15] so that it can be used to obtain data about someone’s cognitive process. The high ability students were asked to solve the ill-structured problem using think-aloud method. They were asked to verbalized their problem solving process as they work through the problem. After that, a follow-up interview was conducted to complete the lacking data from think-aloud process.

The validity was done with time triangulation technique. The think-aloud interview was conducted two times. There are two ill-structured problems used for each think-aloud session. For each session, the problems has the same difficulty level. The problems’ topic were geometry. Data were considered valid if it showed consistency between the first and second think-aloud session.

The ill-structured problem used for each think-aloud session was design problem and decision-making problem. The first problem was design problem. Students were asked to make more than one backyard design according to the area and location of each room that was known in the problem. The second problem was decision-making. Students were asked to find the area painted, decide the paint, and calculate the cost. The wall’s size (length and width), the paint pattern, and the price of each paint were known.
3. Result and Discussion

Time triangulation was conducted in this research. The triangulation result showed that the subjects was consistent in the first and second think-aloud, so it can be concluded that the data of the first think-aloud is credible. Therefore, the creative thinking process data that will be presented is only the first think-aloud data. Based on the data analysis, the creative thinking process include preparation, incubation, illumination, and verification. These process can be explained as follows.

3.1. Preparation

During the preparation stage, in the first and second problem S1 and S2 read the problems carefully. In the first problem, they underlined the important informations from the problem. This activity was intended to make it easier to find the information needed. After that, they wrote the underlined informations on their answer sheet using their own language.

In the second problem, after reading the problems they examined the paint pattern and the paints’ information from the problem. They wrote the informations known and asked from the problems in their answer sheet. Both subjects wrote the informations using their own language to make it easier to understand.

3.2. Incubation

In the incubation stage, after reading the problem and collected informations from the problem, the subjects tend to silent for a while. They silent but keep thinking to find the problem solution continuously. The subjects reread the informations collected in the preparation stage many times. This activity is intended to seek possible solutions based on the informations that have been obtained. The subjects did these activities when solving the first and second problem.

In the second problem, the subjects made an illustration of the actual problem situation to emerge an inspiration. This illustration help the subjects to emerge an inspiration. S2 draw the problem illustration on her answer sheet. It can be seen at Figure 1. Whereas S1 only imagine the illustration of the actual problem situation. The related interview can be seen as follows:

\[ R : \text{When working on the problem, you see the wall and move your hands like this. What are you doing?} \]
\[ S1 : \text{I imagine the wall have a door and the pattern was painted on it.} \]

\[ \text{Figure 1. Problem illustration made by S2} \]

After imagined the problem illustration S1 remembered that he had solved a similar problem. S1 recall the idea of solving the previous problem. After that subject connected that idea to the current problem to get a solution idea. The related interview with S1 can be seen as follows:

\[ R : \text{How do you get the idea to solve this problem?} \]
\[ S1 : \text{I have an experience in solving a problem like this.} \]
\[ R : \text{Have you ever meet this problem before?} \]
\[ S1 : \text{Not the same problem, just a similar problem. There’s a wall, the width and length are known. Someone want to wallpaper that wall. The wallpaper’s size are known.} \]
How many wallpaper do we need? In that problem I just calculate the wall’s area and divided by the wallpaper’s area.

R : So you got the key idea from that problem and you connect it to this problem?
S1 : The idea is from the wallpaper problem. But this problem is more complicated.

3.3. Illumination
In the first problem, both subjects were made two backyard designs correctly. Before made a design, the subjects decide the size (length and width) first and then decide the location. They made the size according to real life, do the size make sense. In deciding the location, both subjects were do an experiment with possible locations first (Figure 2). High ability students considered the possibilities that will occur before made the design. They will start to draw the design once they feel that the size and location is correct.

The subjects tend to made backyard design using square and rectangular shape. They made different designs by changing the room’s location and size. But some rooms like bathroom, gazebo, and swimming pool have the same size. When working on the second design, the subjects tend to look at the first design before decide the location and size for the second design (Figure 3).

Figure 2. S1’s first backyard design
Figure 3. S1’s second backyard design

In the second problem, high-ability students continue to solve the problem based on the idea obtained at the incubation stage. Sometimes in the middle of the problem solving process high-ability students feel confused in deciding the next problem solving steps. When experiencing that, S1 often imagine the problem illustration. S2 was doing the same, she watch the problem illustration many times in solving the problem. The problem illustration help them to remind the idea obtained at incubation stage. The subjects solve the first problem correctly. In the second problem, high-ability students made some mistake in solving the problem.

3.4. Verification
After obtaining the final result, in the first problem S1 rechecked the designs they made. S1 rechecked it whether the designs is in accordance with the size and location requested. S1 also rechecked the calculations of the room’s size. S2 was doing the same. She checked the size and location of the designs. The related interview with S1 can be seen as follows:

R : How do you verify on the design you have made?
S1 : I checked whether this design meets the location and area requested. After that, if the 2 designs are complete, it means that they are finished.

In the second problem, they examined the problem solving step and the illustration of actual problem situation. They do it to verify whether the problem solving steps they have taken are correct. After analyzed the illustration, high ability students found out that she made a mistake on the idea of problem solving so they revise it. After that, they checked the final result again. The subjects also checked their
calculations. Both of them were very careful in their calculation. They always count twice before moving on to the next step.

| Table 1. Creative Thinking Process of High Ability Students |
|----------------------------------------------------------|
| **Stage**   | **Description**                                                                 |
| Preparation | Subjects read the problems carefully, collected informations from the problems, and examined the image attached in the problem. They communicated the informations from the problem with their own language. It means that they understand the problem. |
| Incubation  | Subjects tend to silent but keep thinking to find the solution. They do some activities to find an idea, including reread the information known, made an illustration of the problem situation, and recalled ideas from their experience. |
| Illumination| In the first problem, subjects made two backyard designs. Subjects plan the problem solving carefully. They tend to look at the first design before decide the location and size for the second design. They also consider whether the size makes sense. In the second problem, students continue solve the problem. They continue to solve the problem and often look at the problem illustration from previous stage. |
| Verification| Subjects do some activities to check whether the solution is right or wrong, including checked the calculation, checked the problem solving steps, and revised the wrong ideas. |

Based on the Table 1, in preparation stage high-ability students were understanding the problem well. They were able to communicated the informations known and asked with their own language. This results are in agreement with Wulantina et al., high ability students collect the information known accurately and identify the problem asked well [16]. High ability students usually conscientious. They try to get an insight into the problem carefully.

In incubation stage, high-ability students tend to silent but still thinking to find a solution. In incubation stage students do things that lead to problem-solving ideas [7]. They reread the information known and made an illustration about the problem situation to find an idea. The problem illustration helps them to understand the real situation so they can find an idea to solve the problem. In this stage they also recalled the ideas from their experiences. They found an idea to solve the problem by recalled the ideas from their experiences.

In illumination stage, before meet another ideas high ability students tend to look at the first design. They analyzed the previous idea to get the other idea. The result is in agreement to research conduct by Wulantina, high ability students find the other ideas by understanding how to solve the previous idea and find the solution by continuing the initial idea that have been found before [16].

The subjects also consider whether the size makes sense. It means that they plan the problem solving carefully and connected mathematics ideas to the reality. In this stage, high-ability students often look at the illustration from incubation stage when solve the problem. They continue to solve the problem using the idea obtained from the previous stage. It is in relevant to research conduct by Puspitasari, high achievement students’ problem solving steps and strategies are structured, detailed and systematic [17].

In verification stage, students do some activities to check the final solution. This result is relevant to the research conducted by Sari, high-ability students re examined the formulas used, the steps, and the answers they get [18]. S1 and S2 checked the calculation and the problem solving steps, and revised the wrong ideas. In this stage, students need to used their critical and convergent thinking.

Bart et al. stated that students with high ability in mathematics were tend to rely on their memorization and application of knowledge than produce ideas [19]. However, the result showed that high ability students do more than memorize and apply. In incubation stage, they connecting their experience to the current problem to get problem-solving ideas. While in the illumination stage, they
made more than one backyard which means that they produce novel ideas. High ability students may understand the lesson well, so they may emerge novel ideas easier.

High ability students also meet difficulty to provide divergent solution in mathematics [20]. They can’t found another way to solve the second problem. Furthermore, this can be seen from the time they takes to complete those two problems. S1 and S2 take around 30 minutes to solve each question.

4. Conclusion

Based on the findings, it can be concluded that in preparation stage high ability students were understand the problem, they collected informations from the problem. In incubation stage, high ability students silent for a while, reread information known from the problem, made an illustration from the problem situation, and recalled ideas from their experience. In illumination stage, high ability students found another idea by analyzing the idea that obtained before, planned the solution carefully, connected mathematic ideas to the real situation, and continued solve the problem. In verification stage, high ability students checked the calculation, verified the problem solving ideas, and revised the invalid problem solving ideas.

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