The students’ creative thinking process in solving mathematics problem based on wallas’ stages

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Abstract. Knowing the students’ creative thinking process in solving mathematics problem is so important for the teacher, so that teacher is able to detect the students’ error. This qualitative research aims to describe the students’ creative thinking process in solving probability problem based on Wallas’s stages. This research can be used as an educational reference and help teachers to motivate their students to improve their creative thinking process in solving mathematical problems. The subject of this study consists of 3 students from Matthayom 3/1 Thailand, which have fair (S1), low (S2), and very low (S3) ability in problem solving skill. The data is collected by test and interview. This research indicates that in preparation stage, S1 is able to convey the known and asked data. S2 tends to explain what is known and asked using similar sentences which contains on the question. S3 is not able to explain what is initial in formation completely. In incubation stage, S1 can easily think the solution, though it is wrong. S2 thinks for a while to get the solution and focusing on the other things that are not meaningful. S3 is silent for long time to think the problems’ solution. In illumination stage, S1 and S2 get idea to solve the problem, but the result is wrong. S3 fails to find any ideas to solve it. In verification stage, S1 re-check the solution before drawing the proper conclusion, although it is not suitable on the question. S2 and S3 do not re-check the answer written.

1. Introduction
Facing the future challenge and competition which is stricter does not only need an educational output that is skilled in one field but it also needs an educational output having creativity to develop the other fields [5]. Thus, the development of creative thinking can be the center of education where the students are free to convey their own new solution. The creativity does not only occur in some fields, such as art, literature, and science, but it also occurs in other fields, including mathematics [6]. In fact, mathematics is regard as a difficult subject for students, because it is abstract and needs high order thinking to solve problem related to it. That statement is supported by the result of research conducted by Maharani et al. who conclude that the level of students’ creative thinking skill in mathematics is almost not creative.

Problem solving is absolutely related to creative thinking. One of the ways to encourage the students to think creatively in mathematics learning is making them all accustomed to solving problem. The students do not get theories or mathematics formulas, but they are also taught to be accustomed solving problem that their understanding toward concept is more meaningful [2]. Knowing the students’ creative thinking process in solving mathematics problem is so important for the teacher. By knowing the students’ creative thinking process, the teacher is able to detect the students’ error. Each of students surely has different characteristics on each stage of creative thinking, including the process of it [9]. The students’ error can be used as an educational reference for the students. Also, the teacher can design the learning process which is suitable with the students’ thinking process.

The question used in this study is contextual question which topic is probability. This study aims to indicate the students’ creative thinking process in solving contextual problem related to probability lesson. To indicate the students’ creative thinking process in solving problem, it uses the Wallas’ thinking indicator which consists of four stages. They are preparation, incubation, illumination, and verification. The indicators of verification stage are (1) the students can understand the problem; (2) the students can identify the elements which is known, asked, and needed; (3) the students can convey
by their own way. The indicator of incubation stage is when the students have self-reflection to get solution of problem by writing the way to solve the problem. The indicator of illumination stage is the student finding and writing more than one idea to solve the problem correctly. It refers that it complies the aspect of creative thinking including fluency, newness, and detail. The indicator of verification stage is when the students test and re-test the validity of the solution gained to prove that it is true [7].

2. Methodology
This is a descriptive study with qualitative approach which focuses to gain information as the basis to make a description of students’ creative thinking process on Matthayom 3/1 in solving the mathematics problem. The instrument used in this study consists of problem-solving equipment which topic is probability and interview guidance.

The problem solving test in this study is an essay consisting of two questions which right answer is more than one. The validity of instrument which will be used must be tested based on the content, construction, and language. The validity toward both of instruments is conducted by two lecturers and one mathematics teacher. The determination of the level of research instrument validity is based on Table 1.

| Value of $Va$ | Level of Validity |
|---------------|------------------|
| $1 \leq Va < 2$ | Not Valid        |
| $2 \leq Va < 3$ | Less Valid       |
| $3 \leq Va < 4$ | Valid            |
| $Va = 4$       | Very Valid       |

The data are gained by applying problem solving test which topic is probability. It will be analyzed based on Wallas’ stages, namely preparation, incubation, illumination, and verification. The subject of this study consists of three students on Matthayom 3/1. They are chosen by purposive sampling technique which is based on their ability. They are chosen to take an interview which will discuss more about their creative thinking process based on the answer sheet of problem-solving test gained.

The procedures of this study are (1) making the students do the problem-solving test; (2) analyzing the result of students’ work in solving mathematics problem which aims to identify their problem solving skill; (3) categorizing the students based on their problem solving skill; (4) conducting an interview; (5) analyzing the result of interview.

3. Result and Discussion

3.1. Result
The data are collected by making 31 students on Matthayom 3/1 do the problem-solving test which consists of two question. The time allocation is 40 minutes. The instrument has already passed the validity process previously. The validity is conducted by two lecturer and one mathematics teacher. The result of the validity is below.

| Aspect | V1 | Average | V2 | Average | V3 | Average | $I_i$ | $V_a$ |
|--------|----|---------|----|---------|----|---------|------|------|
| 1      | 4  | 4       | 4  | 4       | 4  | 4       | 4    | 4    |
| 2      | 4  | 4       | 4  | 4       | 4  | 4       | 3.4  | 3.83 |
| 3      | 4  | 4       | 4  | 4       | 4  | 4       | 3    | 3.67 |

$V_1$ : first validator
$V_2$ : second validator
$V_3$ : third validator
Aspect 1 : content
Aspect 2 : construction of solving
Aspect 3 : construction of Wallas’ stages
Aspect 4 : language
Table 3. The Result of Problem-Solving Test Validity

| Aspect | V1 | V2 | V3 | I_1 | V_o |
|--------|----|----|----|-----|-----|
| 1      | 4  | 4  | 4  | 4   | 4   |
| 2      | 4  | 4  | 4  | 4   | 4   |
| 3      | 4  | 4  | 4  | 4   | 4   |

Aspect 1: the question given reflects the students’ creative thinking process in solving mathematics problem which topic is probability

Aspect 2: the question given reflects the use of well and correct language

Aspect 3: the question given reflects that it is related to the previous question

A research instrument is valid, if it has value \( V_o \geq 3 \). Based on the total average gaining the level of validity instrument on the Table 1, the problem-solving test and interview can be used. After the data are gained, the result of problem-solving test is analyzed. Then the students are categorized based on their problem-solving skill. The result of analyzing 31 students indicates 16 students having fair problem-solving skill (51.61%), 12 students having low problem-solving skill (38.71%), and 3 students having very low problem-solving skill (9.68%). Then on each category, it chooses a representative who has the highest score to be inter viewed. It gains 3 students which consists of one student having fair problem-solving skill (S1), one student having low problem-solving skill (S2), and one student very low problem-solving skill (S3). The category of the subject of research is on the Table 4. The result of students’ problem-solving test to indicate the thinking process and indicator achievement are different.

Table 4. Subject of Research

| Student’s Code | Score of Problem Solving (%) | Category |
|----------------|-----------------------------|----------|
| S1             | 55                          | Fair     |
| S2             | 35                          | Low      |
| S3             | 5                           | Very Low |

Table 5. Indicator Achievement

| Wallas’ Stages          | Indicators                                           | S1 | S2 | S3 |
|-------------------------|------------------------------------------------------|----|----|----|
| Preparation             | Understanding the problem                            | ✓  | ✓  | ✓  |
|                         | Identifying the elements which is known and asked    | ✓  | ✓  | ✓  |
|                         | Element sufficiency needed                           | ✓  | ✓  | ✓  |
|                         | Conveying by own way                                 | ✓  | ✗  | ✗  |
| Incubation              | Reflecting to find the solution                      | ✓  | ✗  | ✗  |
|                         | Writing the solution phases                          | ✓  | ✗  | ✗  |
| Illumination            | Finding and writing more than one idea to solve      | ✗  | ✗  | ✗  |
|                         | problem correctly                                    |    |    |    |
| Verification            | Test and re-test the validity of solution gained     | ✗  | ✗  | ✗  |

3.2. Discussion

Based on the study which is conducted, it indicates that the students who have fair problem-solving skill in each Wallas’ creative stage are more dominant than the students who have low or very low problem-solving skill. The high or very high category in each Wallas’ creative stage is nothing. The problem given to the students consists of problem 1 (M1) and problem 2 (M2). It is on the Table 6.

Table 6. The Problem Presented

| No | Problem |
|----|---------|
|    | *In a box there are eight identical balls that are numbered 1, 2, 3, ..., 8. From the box are taken two balls in two shots with returns. Make two events, say event A and B are Independent! Prove your answer!* |

3
The four front numbers John’s friend’s apartment consisted of different numbers. At the time John would visit his friend, he forgot the four digits of the apartment’s front number. How many apartment numbers can John find?

After the data analysis is conducted, it gains the result of test or interview. The students’ creative thinking process in solving problem related to probability based on Wallas’ stages in each subject of research is on the Table 7.

| Subject | Category | Wallas’ Creative Thinking Stages | Preparation | Incubation | Illumination | Verification |
|---------|----------|---------------------------------|-------------|------------|-------------|--------------|
| S1      | Fair     | Thinking about the step of problem solving by reflecting to focus on the problem given which is presented by writing the step of solution used | Being able to understand the beginning information presented well and being able to tell by own way | Getting and applying one solution idea incorrectly. The idea has been applied correctly, but it is less careful in counting that the result is wrong | Testing and retesting the validity of the answer gained. It is not suitable to the data known |
| S2      | Low      | The student does not think the solution directly, but focus on other things. | Being able to understand the beginning information presented well and being able to explain. The way of explanation is like question | Getting one solution idea. The students explain his idea without counting that the result is not gained | Being not rechecking the result gained |
| S3      | Very Low | The student does not think about the solution of the problem given directly. | The student understands the problem but he does not write the beginning information asked. When the the student is interviewed, he cannot convey the data known and asked | Not getting and applying the solution. The student looks confused and silent when he is asked about the steps of solution toward the problem given. | Not rechecking the answer, because no answer on the answer sheet |
Based on the result of analysis which is on the Table 7, the next one discusses the creative thinking process based on Wallas stages in solving problem related to probability lesson. The result of analysis conducted indicates that the students who are in difficult generally able to understand the beginning information well.

The students who are in fair category are able to understand the problem well. They can identify the elements known and asked, and sufficiency of elements needed. Besides identifying the data known or the data asked correctly, the students are also able to convey it by their own way. Although it is a little bit complicated to convey it, but the point of the problem can be conveyed correctly. The result of this research is relevant to the research conducted by Maharani et al., (2017) which conclude that the students who are in fair category in preparation stage can identify the problem well. S2 and S3 are not able to understand the problem completely. It can be observed by the students who have not identified and sufficiency of information needed.

In general, the students in each category of problem-solving skill has difference to pass this incubation stage. According to Carr (in Sitorus, 2016), it is explained that the activities in incubation stage are various from the different individual or the same individual which refers different behavior during a period or opportunity.

In this stage, S1 is silent awhile to think the way to solve the problem and focuses on the problem given. The expression of silence is the beginning way, where the students let their mind rest and try to find new idea. The students in fair category write their way to solve the problem on the answer sheet, but they have not succeeded to apply their idea yet, because the result is wrong. It is different from S1, S2, and S3. They need such a long time to think the solution of the problem.

The illumination stage indicates the students complying their thinking aspects or not. The thinking aspects are fluency, newness and detail. In this stage, the difference of each category of problem solving will be visible. The data analysis indicates that S1, S2 dan S3 is not able enough to ideas in solving the problem because they can get one alternative answer only. It occurs, because the students have less understanding toward the problem and they are not accustomed to have more alternative answer.

Based on the figure 1, the students (S1) answer the question simply based on their understanding toward problem given. The students believe in their own idea, but they make a mistake in solving the problem. When solving the problem, the students are only able to get one solution and the result is wrong. The idea and steps of solution used are right, but they are less careful that the result is wrong. S2 only explain the idea which will be used in general without counting. S3 has not got or applied the solution idea. According to the theory said by Gotoh, S1, S2, and S3 are in not creative category, because in this stage they make a mistake and are not an awareness to find new things.

![Figure 1. The Answer of the Students (S1) in Illumination Stage](image-url)
The last stage is verification. The result of study indicates that the students (S1) who have fair problem-solving skill re-check the validity of the solution gained, but not consider something relevant. The students who are in low or very low category, namely S2 and S3 do not re-check the answer.

4. Conclusion
After analyzing the students’ creative thinking process in solving mathematics problem based on Wallas’ stages, it gains some results. In preparation stage, the students are in fair category and comply all indicators in this stage. The students are able to convey the data known and asked by their own way. The students who are in low and very low category convey the data known and asked by using a sentence which is similar to the question. The students who are in very low category are not able to mention the beginning information completely. In incubation stage, the students who are in fair category are silent awhile think about the solution and focus on the problem. The students who are in low and very low category are silent for such a long time and focus on other things which are not important. In illumination stage, the students who are in fair category are able to gain and apply one solution idea, but the result is wrong. The students who are in low and very category is not able to gain and apply the solution idea correctly. In verification stage, the students who are in low and very low stage do not re-check the answer written. The students who are in fair category re-check the validity of solution gained but the result is not suitable on the data on the question.

Based on the conclusion gained, it indicates that the students need more intensive guidance by the teachers to help them pass each stage in creative thinking process. The teachers give more guidance and motivation to the students doing something incorrectly until they gain the solution.

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