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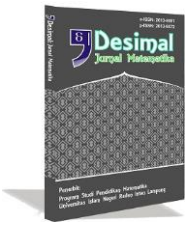

# Analysis of metacognition skills with students' generalization abilities

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**ABSTRACT**

*This research was conducted with the aim of describing metacognitive skills with students' mathematical generalization abilities in problem solving. This type of research is a qualitative descriptive research. This research was conducted on $9^{th}$ grade students by taking 5 students as research subjects. Data collection techniques used in this research were tests, interviews, and questionnaires. The results of this research indicate that students are able to apply the designs that they will use to solve problems. Even though the evaluation indicators only review the results obtained.*

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## INTRODUCTION

Mathematics is a subject that requires calculation in every lesson. Not only calculations are required, but also how students are able to solve a problem. Considering the importance of mathematics, there is nothing wrong if mathematics is given to students of all levels of education. Regarding the importance of mathematics in schools, (Kemendikbud, 2014) stated that the purpose of mathematics lessons is to master mathematical concepts, including competence in explaining the relationship between concepts and using concepts or algorithms in a flexible, accurate, effective, and precise way in solving problems.

So far, students have less knowledge of their own abilities, so students still have difficulty in problem solving. Students' problem-solving awareness also shows students' metacognitive characteristics. In July 2017, the Indonesian team consisting of four people won third place in the championship of International Mathematics PO Leung Kuk $20^{th}$ Primary Mathematics World Contest (Indonesia Better, 2017), although it only came out as third place, Indonesia has successfully competed with teams from developed countries such as China and America.

However, Indonesia should be able to become the first winner in a prestigious competition like this. The background of student input that causes differences in the problem-solving abilities of each student. According to Astutiningtyas (2017) metacognition is a person's knowledge of cognitive activities or activities in planning, monitoring, and evaluating the resolution of a problem. Likewise with Chairani (2016) who said that metacognition is a person's understanding of his own cognitive process which is linked to knowledge of tasks, learning strategies, and knowledge that a person has. Meanwhile, metacognition skills are students' abilities or expertise in applying or practicing the knowledge they have acquired.

Indicators related to metacognition skills stated by Lee et al. (2019) are recognizing and defining problems, mentally representing problems, designing how to proceed, evaluating what is known about one's own performance. Meanwhile, according to Chairani (2016) indicators related to metacognitive skills are understanding in planning at the problem-solving stage, carry out monitoring at each stage of problem-solving implementation, and understanding in carrying out assessments at each stage of problem-solving implementation. Based on several expert opinions, authors conclude that the indicators of metacognition skills are the planning process, the monitoring process, and the evaluation process.

Generalization according to Lesmana et al. (2018) is one of the activities that are categorized as inductive reasoning and meaningful aspects of the thinking process. Another opinion was also expressed by Anggoro (2016), generalization or formulating is the stage to master the core derived from the lesson modules that have been presented. Generalization is part of inductive reasoning (Shadiq, 2013). Based on some of the definitions that have been put forward, it can be concluded that the ability to generalize is a process used to draw general conclusions generated from a number of data observations. The generalization ability indicators used in this research are perception of generality, expression of generality, symbolic and manipulation of generality.

Based on the research conducted by Ardhilah et al. (2020) entitled "Metacognition and Learning Independence of Junior High School Students in Reading Mathematics Books on Cartesian Coordinate Materials" shows that metacognitive attitudes will work very well if students are accustomed to being given problems and then the students are guided to be able to solve them. In this research, metacognition is also in line with student learning independence, that are students who excel in mathematics subject, have excellent learning independence and high metacognitive skills.

Another research conducted by Lesmana et al. (2018) entitled "Improving Mathematical Generalization Ability and Self-Confidence of Junior High School Students with Metaphorical Thinking Approach" shows that the generalization ability of students who use a metaphorical thinking approach is better than students who use ordinary learning. Based on researches above, these results indicate that the generalization ability and metacognition skills both have similarities in the mathematics learning process of students in class, and metacognition skills can be expressed in the form of a self-assessment in the form of a questionnaire combined with a test, which is expected to have a very good impact on student activity and overall are very good. So, in this research, adopting some of the results of the research above and then collaborating, so that the purpose of this research is to determine the effect of

metacognition skills with students' generalization abilities.

## METHOD

The research method used in this research is descriptive qualitative. The subjects of this research were 5 of 11th grade students, because they had received and studied the material for sequences and series, and also seen from the daily lives of students who actively communicated in order to obtain complete information from the results of the work. The data collection technique used a written test consisting of 2 questions of mathematical generalization ability, a questionnaire consisting of 25 statements, and interviews. The data analysis based on achievement indicators to see students' metacognitive skills and mathematical generalization abilities. This research is measured by 2 types of indicators, namely: Metacognition skill indicators: (1) planning process, (2) monitoring process, (3) evaluation process; and Indicators of generalization ability: (1) perception of generality, (2) expression of generality, (3) symbolic expression of generality and manipulation of generality.

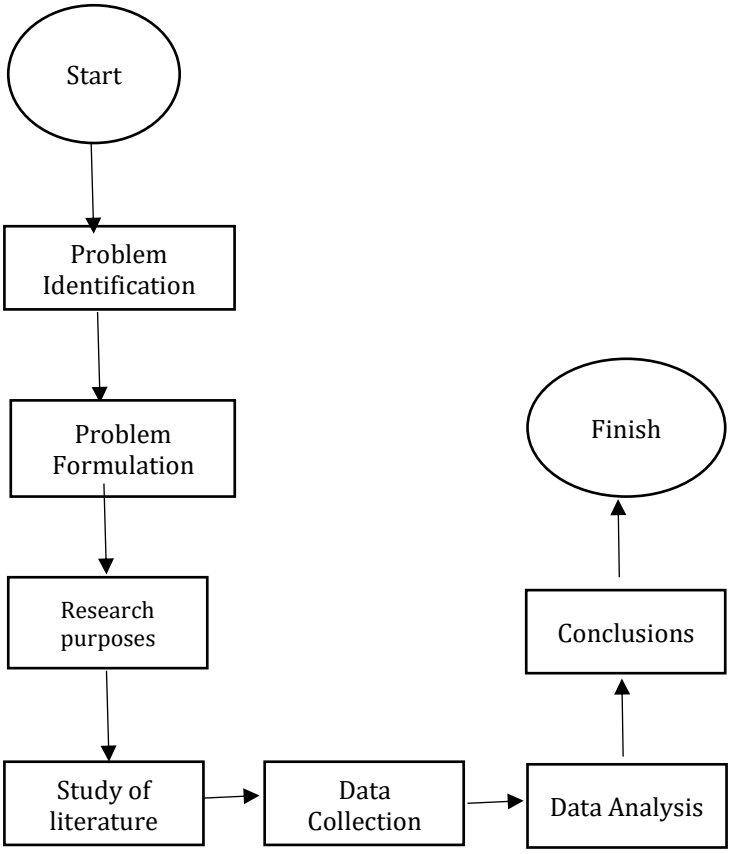


**Figure 1**. Research Flowchart

## RESULTS AND DISCUSSION

Based on the results of research data that has been carried out by 5 students, the data obtained in this research containing data on metacognition skills and mathematical generalization abilities. Data on metacognition skills were obtained through questionnaires while data on generalization abilities were obtained from test results that measured students' generalization abilities.

The generalization ability data can be seen in Table 1. on the first indicator,

the perception of generality stage. At this stage students are able to identify or recognize a pattern as expected. Students already know that the problems or questions presented have rules/patterns related to the length of the sides of a rhombus. In question 1a (in Figure 2).

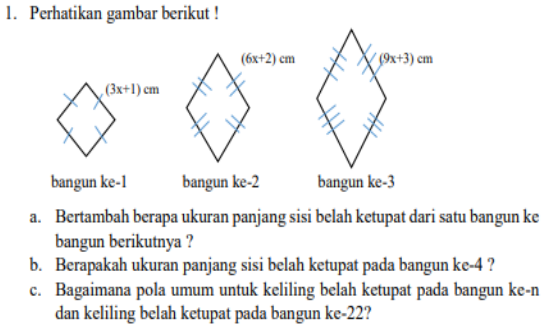


**Figure 2**. Question 1a

Students are given an example of the change in the length of the sides of a rhombus. Students are instructed to analyze the changes that occur and look for patterns to build the next rhombus. S1, S2, S3, S4, and S5 are able to write clear and relevant information that is used to complete the stage of deciphering the pattern. However, S2, S3, and S4 were less optimal in calculating the final result, so the solution is not optimal in the stage of deciphering the pattern (in Figure 3). In line with Radford (2003) that at the generalization stage, students have the ability to perceive similarities seen from several elements of a sequence, so at this stage students can find regularities between patterns. Another opinion is also explained by Clements & Sarama (2018) which indicates that the pictures that children gave to them through symbols (such as words or numbers) are for children to understand. While in question number 2, students are given a contextual problem that is connected with the current event and directed to solve the problem by looking at the formula or pattern of the concept of sequences and series. To solve the problem students are asked to translate the problem into the form of the pattern used, so that S1, S2, S3, S4, and S5 already understand about describing the pattern.

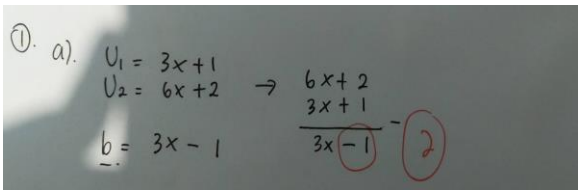


**Figure 3**. The Example of Student Answer

The second indicator, the expression of generality stage, at this stage students are expected to be able to use the results of identification or pattern recognition used to determine the next data/term. In questions number 1b, S1, S2, S3, S4, and S5 can use the results of pattern identification and can solve them relevantly. Then all students also succeeded in writing the rules in verbal language, it was seen on the answer sheet which wrote down the pattern rules to determine the length of the side of the next rhombus. Although there are some students, S2, S3, and S4 who are still not optimal in completing the final results of their answers, because there is a correlation between the results of the answers to the previous questions that affect the answers on number 1b (in Figure 4). Even though based on the results of the interviews, other students also knew the pattern rules used, but they were less careful in calculating the final results. Question number 2 (in Figure 5) S1, S2, S3, S4, and S5 are also able to use the results of pattern identification easily because in the previous question students have been able to translate the pattern of questions requested from a contextual problem.

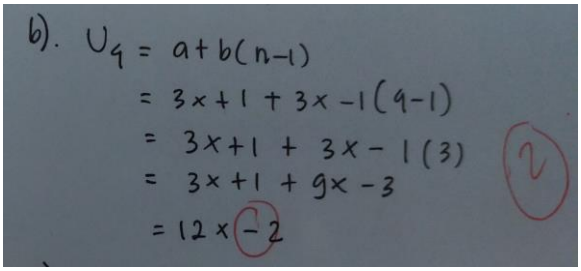


**Figure 4**. The Example of Student Answer

2. Hasil observasi pada penderita Covid-19 disuatu negara, ditemukan virus yang menyebabkan pernapasan penderita akan semakin sesak. Untuk mencegah pertumbuhan dan sekaligus mengurangi jumlah virus, penderita diberikan vaksin yang diharapkan dapat mengurangi virus sebanyak 20% pada setiap dua hari sekali. Jika pada awal observasi (hari ke-1) terdapat sekitar 6.250 virus dan langsung diberikan vaksin pertama, perkirakan jumlah virus setelah pemberian obat pada hari ke-7 adalah …

**Figure 5**. Question 2

The third indicator, the symbolic and manipulation of generality stage, at this stage students must be able to produce general rules and patterns. At this stage students are also able to use generalized results to solve problems, and apply the rules/patterns that they found on various problems. In question 1, all S1, S2, S3, S4, and S5 students succeeded in formulating generalizations symbolically. While at the problem-solving stage, and the ability to apply the rules/patterns that they found on various problems, in this case students do not need to solve other problems. In question number 2, S1, S2, S3, S4, and S5 (in Figure 6) can also apply rules/patterns by generalizing these patterns so that they get a rule to solve the problem. This is in accordance with research conducted by Dinarti et al. (2019) This is in accordance with the research conducted by Budi that most students begin to generalize by observing the picture, then build appropriate relationships, and the last stage is to determine the general form that will be applied to the general formula.

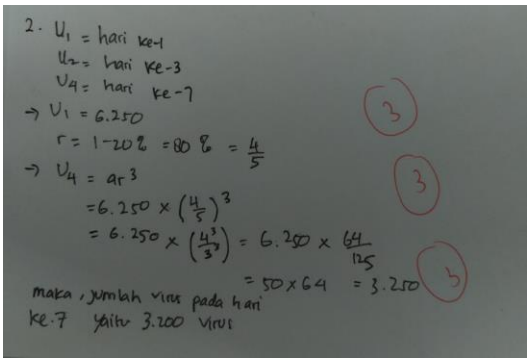


**Figure 6**. The Example of Student Answer

**Table 1**. The Percentage of Students at the Generalization Stage

| No. | Generalization Stage | Percentage |
|---|---|---|
| 1. | *Perception of Generality* | 96% |
| 2. | *Expression of Generality* | 100% |
| 3. | *Symbolic and Manipulation of Generality* | 98% |

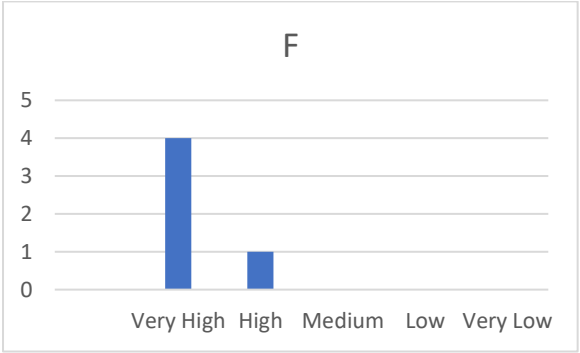


**Figure 7**. Data Analysis Chart

Based on the research that has been done by 5 students, the metacognition skill questionnaire of 25 statements as a percentage of all students shows very good results. The percentage of all students is 80% for the very high category and 20% for the high category. From this result, students are able to assess themselves. Students have been able to assess what they will do in problem solving. This causes the achievement or realization of indicators of metacognitive skills that are in line with the results of the written test. This is in accordance with research conducted by Anggo et al. (2014) that by using metacognition, students can carry out all activities with full awareness. Every step of the mathematical problem-solving thinking process is fully considered.

## CONCLUSIONS AND SUGGESTIONS

Based on the results and discussion, it can be concluded that students have good metacognitive skills because they have achieved all indicators of metacognition skills, they understand what they have to plan before solving a problem and implementing what they have designed. This is evident in the test

results. Although the evaluation process indicators only review the results obtained.

Based on these conclusions, the authors suggest for further researchers, that the criteria for selecting research subjects to be more clarified. Future researchers are expected to conduct this research by involving a wider sample.

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