Adaptive and innovative students’ metacognition in solving logarithm tasks

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Abstract. Problem solving as approach in teaching and learning has important position to face students’ future. Students’ problem-solving skill and knowledge depend on several aspects, one of which is metacognition. Metacognition is the awareness of students in using their minds to plan, monitor, and evaluate the cognitive processes and strategies used. Students have different cognitive styles, including adaptive and innovative style. The selection of participants in this qualitative study used a cognitive style questionnaire to find students who had cognitive styles of adaptation and innovation. Data collection using task-based interviews about algorithms. Analysis of research results from the 10th grade students as participants used steps that are data reduction, data presentation, and verification, as well as checking data validity. The results showed that adaptive student at planning stage to understand the problem through reading effort, solve the logarithm problem using her knowledge directly, and plan to check the calculation, writing, and methods used. In monitoring stage, she did not estimate time consuming for solving problem. Student have not been confident yet that her plan was correct. She thinks that she has forgotten, although using methods for checking of solution was correct. Finally, at evaluation stage, adaptive students have no other way to understand problem, believes that his knowledge could help to solving problems, look back the plan that has been used, and she has no other way to re-examine his work. The innovative student has several similar stages with the adaptive student. She has estimated time consuming for solving logarithm problem and check calculation results, writing, and methods used. She has been confident using his method to understand problem, and check his work twice until it was correct. He has alternative strategy although the alternative is more complicated so it is not used.

1. Introduction

Problem solving is one of the important aspects in learning mathematics. The most important goals in learning mathematics are to improve the student ability, mathematics achievement and develop the students’ skills in solving mathematical problems [1]. In line with that statement, [2] explains that the skills in solving the problems can be used as a means for the students to have an accurate, logical, critical, and creative way of thinking. Therefore, problem solving becomes one of the important aspects in learning mathematics. To obtain optimal results and benefits in solving mathematical problems, it must be done through well-organized problem-solving steps. One of ways to organize mathematical problem solving is as stated by Polya which includes 4 steps. Those are as follows: (1) understanding the problem, (2) determining the problem-solving plan, (3) working according to the plan, (4) looking back at the results obtained.

Instead of the steps proposed by Polya, there are other factors which can influence the success in solving problems, namely metacognition [3]. Saricam & Ogurlu (2015) define metacognition as thinking...
about thinking. “Metacognition means an individual’s awareness of his own thinking processes and his ability to control these processes” [5]. Metacognitive processes play an important role in problem solving. This is supported by the opinion from [6] who explain that “Metacognition is of particular importance in the process of mathematical problem solving”. Metacognition is the most important part in the process of solving mathematical problems. Saricam & Ogurlu (2015) explain that “Metacognition is of importance to academic performance, problem solving, and student learning”. Agree with that, [7] states that “…metacognition as a key component of problem-solving process”. [5] confirmed that “Studies on metacognition have proven that there is a strong correlation between problem solving and metacognition and that the student with a higher level of metacognition skills become successful in problem solving”. The relationship between metacognition and problem solving is very strong and student with high levels of metacognition skill will be superior in problem solving. In line that, [8] states that “For the successful solution of any complex problem-solving task a variety of metacognitive processes is necessary. It is known that individuals with higher levels of cognitive abilities perform better in problem solving tasks”. Metacognitive processes are needed in solving problems. Students who have high metacognitive abilities will be better in solving problems compared to students who have low metacognitive abilities. On the other hand, [9] states that “…learners who have a good level of self-regulation and metacognitive strategies obtain better academic success”.

Babay & Meamar (2016) said that “Two kinds of effective strategies in problem solving are cognitive strategies and meta-cognitive strategies that are as learning strategies”. There are two strategies which influence the success of problem solving, namely cognitive strategies and metacognitive strategies. Livingston (1997) that “Cognitive strategies are used to help and individual achieve a particular goal (e.g., understanding a text) while metacognitive strategies are used to ensure that the goal has been reached (e.g., quizzing oneself to evaluate one’s understanding of that text)”. [11] are distinguish three phases for metacognitive strategies, namely: (1) planning, planning strategies such as time allocation during learning, (2) monitoring, monitoring strategies for example students repeatedly checking by asking question to themselves whether understanding the material, and (3) evaluation, evaluation strategies where student evaluate the learning process.

Cognitive style is one of the characteristics of individuals that can help to explain the differences in success in the learning process, including metacognition abilities [12]. The application of metacognition activities in learning also needs to pay attention to students’ cognitive style [12]. Cognitive style is closely related to learning activities [13]. On the other hand, that “Cognitive style is closely related to learning activity. For instance, category learning is known as a way in assembling information to learn something”. Based on Kirton’s theory, a cognitive style of person in problem solving can be divided into adaptation cognitive style and innovation cognitive style. Individuals who have adaptation cognitive style tend to do their best when solving problems, and individual who have innovation cognitive style will do different things when solving problems [14]. The adaptor in problem solving tends to use the methods or strategies that have been provided. While innovator tend to use different methods or strategies, even ignoring the methods provided and using new methods or strategies. One cognitive style which is suitable for problem solving is the cognitive style of adaptation and innovation. It was stated by [15] who said "one such theory proposed by Kirton is the theory of Adaptation-Innovation problem solving style". The theory proposed by Kirton is the Adaptation-Innovation theory. [15] states that "the adapter style is characterized by a preference to" do things better "whereas the innovator style is characterized by a preference to "do things differently". Someone who has a cognitive adaptation style has the characteristic to do something better, whereas someone who has a cognitive style of innovation has the characteristic of "doing something different ". Based on the explanation above, the researcher wants to describe adaptive and innovative students’ in solving logarithm tasks in detail. Especially the metacognition in solving logarithm task of students’ who have adaptive and innovative.
2. Method
This research is a descriptive qualitative research which aims to describe the process of the students’ metacognition which have cognitive style adaptation and innovation in solving mathematical problems. The research was conducted in X-IPA1 class at SMA Muhammadiyah 4 Surabaya. The research subjects were 2 students consisting of 1 student with cognitive adaptation style and 1 student with innovative cognitive style. The main instrument is the researcher himself, because the researcher has a role in choosing research subjects, collecting data, analyzing data, and summarizing research results. While the supporting instruments used in this study were the cognitive style adaptation and innovation questionnaire (AI-W scale), Problem Solving Tests, and interview guidelines. The cognitive style adaptation and innovation questionnaire is used to get subjects who have the cognitive style of adaptation and innovation. The problem-solving test contains 2 questions about determining logarithmic values by using characteristic of logarithm. The researchers used this material based on data from the Ministry of Education and Culture, the percentage of absorptive capacity which "determined the value of a logarithmic form" in the 2019 national exam. It was 50.20% which is still less than the standard of 55%. Problem Solving tests are used to find out how students adapt and innovate in solving mathematical problems. Interview guidelines in the form of a list of questions is asked to the research subjects to obtain deeper information relating to the process of metacognition of students in solving mathematical problems.

The subject selection process begins by giving a cognitive style of adaptation and innovation in the form of questionnaire (AI-W scale). It consisted of 9 statements which provide the scale from 1 to 9. The research subject is determined to have cognitive adaptation style if the total score obtained was less than 45 and the research subject is determined to have an innovative cognitive style if the total score obtained was more than 45. After obtaining subjects with cognitive adaptation and innovation, the researcher gives the problem-solving test to the subjects which must be done by each subject. After they did the problem-solving test, the researcher conducted interviews to the subjects to get information about the subject's metacognition process.

3. Results and Discussion
Logarithmic task given to the two chosen subjects for 30 minutes. The task contains two items as follows:

1. Specify the value of $32 \log_2 1$
2. When $2 \log 3 = a$ and $3 \log 5 = b$, please specify the value of $6 \log 75$

3.1. Subjects with adaptation cognitive style (KA)
On the subject of KA, the researcher got the results of the subject’s metacognition process in solving mathematics problems. At the stage of understanding the problem, there were three metacognitive processes, namely planning, monitoring and evaluation. The metacognition process at the planning stage done by the subject to understand the problem and find out the purpose of the problem was by reading the questions provided. At the monitoring stage, it found out that the subject was not sure whether the method used in understanding and knowing the purpose of the problem was correct or not because the subject had not yet thought about the problem solving. In addition, in the monitoring phase, the subject did not estimate the time needed to solve the problem. Furthermore, in the evaluation metacognition stage, the subject did not have alternative ways which were more effective and efficient in understanding the problem.
At the problem-solving stage called making a problem-solving plan, there were also three metacognitive processes which consisted of planning, monitoring, and evaluating. The planning stage was done by the subject after understanding the purpose of the problem, the subject planned to work on the problem directly. In addition, the subject used the knowledge he already had to solve the problem. Those were the knowledge of logarithms, exponents, and the characteristics of logarithms. At the monitoring stage, the subject felt doubtful whether the strategic plan used to solve the problem was correct or not because the subject was not sure how to solve the problem. In the evaluation stage, the subject was confident that his knowledge helped him a lot in solving the problem. The subject actually had a more effective and efficient alternative to the chosen strategic plan but the subject forgot it.

At the stage of implementing the problem-solving plan, the metacognition process consisted of three stages. Those were planning, monitoring, and evaluation. In the planning stage, the subject directly implemented the problem-solving plan. The subject was not sure that the knowledge used to solve the problem was correct or not. Then, in the evaluation phase, the subject re-examined the strategy plan procedures which had been used.

The last step in problem solving was to re-examine the results of the problem solving. The three stages of the metacognition process were planning, monitoring and evaluation. At the planning stage, the subject planned to recall when he checked the results of his work. The subject rechecked the calculation, writing, and methods used to solve the problem. The second stage was the monitoring stage. In this stage, the subject thought that the method used to check the results of its completion was correct. In addition, the subject needed to re-examine the results of his work more thoroughly to minimize the errors. The last stage was evaluation. In this stage, the subject had no other way to check the results of his work.

Researcher : Is there any way to solve the problem?
Subject: : No, because I solve this problem according to the way in the book.

Based on the Kirton’s Theory and the interview excerpt, it was known that the KA subjects did the problem-solving test based on the knowledge which they remembered and they did it well. It was in line with the theory of cognitive adaptation styles which stated that the students tended to do well and find solutions in accordance with the concepts which had been accepted.
3.2. Subjects with the innovation cognitive style (KI)

On the subject of KI, the researcher got the results of the subject’s metacognition process in solving mathematical problems. At the stage of understanding the problem, there were three metacognitive processes. Those were planning, monitoring and evaluation. The metacognition process at the planning stage done by the subject to understand the problem and find out the purpose of the problem was by reading and remembering his experience when he learnt logarithms. At the monitoring stage, the subject was sure that the method he used in understanding and knowing the purpose of the problem was correct since he remembered the way in the book was same as what he thought. In addition, the subjects estimated the time needed to solve the problem as quickly as possible in this stage. In the evaluation metacognition stage, the subject did not have alternative ways which were more effective and efficient in understanding the problem.

![Figure 2. The Answer of Subject with Adaptation Cognitive Style](image)

At the problem-solving stage called as making a problem-solving plan stage, there were also three metacognitive processes which consisted of planning, monitoring, and evaluating. The planning stage was done by the subject after understanding the purpose of the problem, the subject planned to directly work on the problem. In addition, the subject used the knowledge he already had to solve the problem. Those were the knowledge of logarithms, exponents, and the characteristics of logarithms. At the monitoring stage, the subject was sure that the strategic plan used to solve the problem was correct. At the evaluation stage, the subject was confident that the knowledge he had can help him so much in solving the problem. The subject had an alternative strategic plan but the subject thought that his alternative way was more complicated.

At the stage of implementing a problem-solving plan, the metacognition process consisted of three stages, namely planning, monitoring, and evaluation. At the planning stage, the subject immediately implemented a problem-solving plan. At the monitoring stage, the subject was convinced that the procedure he was doing was right. The subject believed that the knowledge used to solve the problem was correct. In the evaluation phase, the subject reexamined the strategic plan procedures that had been used.

The last step in problem solving was to re-examine the results of the problem solving. The three stages of the metacognition process were planning, monitoring and evaluation. At the planning stage, the subject planned to recalculate was work when he checked the results of his work. The subject rechecked the calculation, writing, and methods used to solve the problem. The second stage was the monitoring stage. In this phase, the subject thought that the method used to check the results of its
completion was correct. In addition, the subject needed to re-examine the results of his work more thoroughly to minimize the occurrence of errors. The last stage was evaluation stage. In this phase, the subject had no other way to check the results of his work. 

Researcher  : Is there any other way to solve the problem?
Subject  : Yes, but the other way that I think it fits what’s in the book and it’s long. So I used my own way which is shorter and faster.

Based on the Kirton’s Theory and the interview excerpt, it could be concluded that the metacognition process carried out by the KI subject was appropriate to the theory of innovation cognitive style which states that KI subject had different ways to complete the given Problem Solving Test.

4. Conclusion
Adaptive student used metacognition stages when she solves the algorithm problem in accordance with her knowledge who remembered and carried out well. It is in line with the theory of cognitive adaptation styles which states that the students tend to do well and find solutions in accordance with the concepts which have been accepted.

Innovative student used metacognition stages, however it had different with adaptive student. Innovative student had solved the logarithm problem with different ways. She used a faster method and alternative solutions which were consistent with hand book.

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References
[1] Bayat S and Meamar A 2016 Procedia-Social and Behavioral Sciences 2171 p 69
[2] Widjajanti and Djamilah B 2009 Kemampuan Pemecahan Masalah Matematis Mahasiswa Calon Guru Matematika: Apa dan Bagaimana Mengembangkannya. Prosiding Seminar Nasional Matematika dan Pendidikan Matematika Jurusan Pendidikan Matematika FMIPA UNY p 402
[3] Biryukov P 2012 Metacognitive Aspects of Solving Function Problems Procedia-Social and Behavioral Sciences
[4] Saricam H and Ogurlu Ü 2015 Cypriot J. of Edu. Sci. 10 338
[5] Özsoy G and Ataman A 2017 Int. Electr. J. of Elementary Edu. 1 67
[6] Schneider W and Arteh C 2015 Metacognition and Mathematics Education. ZDM Mathematics Education. DOI 10.1007/s11858-010-0240-2
[7] Yıldırım S and Ersözü Z N 2013 Eurasia J. of Math. Sci. & Tech. Edu. 9 411
[8] Christou C Panouara A and Philippou G 2001 Young Pupils’ Metacognitive Ability in Mathematics in Relation to Working Memory and Processing Efficiency Department of Education, University of Siprus
[9] Memnun D S and Hart L C 2012 J. of Int. Edu. Research 8 173
[10] Livingston J A 1997 Metacognition: An Overview from http://www. gse. buffalo. edu/fas/shuel/CEP564 Metacog. html
[11] de Boer H, Donker-Bergstra A S, Kostons D D N M, Korpershoek H, and Van der Werf M P 2013 Effective strategies for self-regulated learning: A meta-analysis (Groningen, NL: GION)
[12] Sudia M, Budayasa I K, and Lukito A 2014 Jurnal Ilmu Pendidikan Universitas Negeri Malang 20 86
[13] Wulandari N H, Widayati K A, and Suryobroto B 2016 J. of Biosciences 23 121
[14] Kirton M J 1976 J. of Appl. Psycho. 61 622
[15] Xu Yin, Tuttle B 2012 Adaption-Innovation at Work: A New Measure of Problem-Solving Styles (Carolina: University of South Carolina)