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Metacognition Process of Students with High Mathematics Anxiety in Mathematics Problem-Solving

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Abstract: This study aims to find out students' metacognition process while solving the mathematics problem. It focuses on analyzing the metacognition process of students with high mathematics anxiety based on Polya's problem solving phases. This study uses qualitative research with case study strategy. The subjects consist of 8 students of 7th grade selected through purposive sampling. Data in the form of Mathematics Anxiety Scale (MAS) result and recorded interview while solving mathematics problems were analyzed qualitatively using Miles and Huberman steps. Before selecting the subjects, the researcher gave the Mathematics Anxiety Scale (MAS) to obtain students with high anxiety. Then, subjects were interviewed while solving the problem to investigate their metacognition process. The results show that: (1) The metacognition processes of students with high anxiety in understanding the problem involve *planning*, *monitoring*, and *evaluating* to explore and understand information of the given problem. (2) The metacognition processes of students with high anxiety in devising a plan involve *planning* and *monitoring* to identify the possible strategy for solving the problem. (3) The metacognition processes of students with high anxiety in carrying out the plan involve *planning* to use the strategy and procedures to find the solution. (4) In the final steps namely looking back, there is no metacognition process of students with high anxiety identified. Thus, it can be said that the high of mathematics anxiety can cause the lack of students' metacognition process while solving the mathematics problem. Therefore, it is important for the teachers to consider students mathematics anxiety to design and plan better mathematics learning.

Keyword: metacognition process, mathematics anxiety, mathematics problem-solving

1. Introduction

Nowadays problem-solving has become mathematics learning process orientation in many countries including Indonesia. Problem-solving is considered as an important and integral component of mathematics learning process. Problem-solving becomes one of process standard [1], and competence [2] in mathematics learning process. Mathematics learning process oriented on problem-solving could improve students thinking ability. It is essential and required for students to face the problem either in learning process context or real-problem context.

Based on the report of *Trends in International Mathematics and Science Study* (TIMSS) 2011 [3], Indonesia ranked 38 of 42 countries with the overall score mean is

386. The result of *Programme for International Student Assessment* (PISA) 2015 [4] showed that Indonesia ranked 63 out of 70 countries regarding with mathematics problem-solving ability. Also, more than 60% Indonesian students were only able to complete the problem under level 2. It indicates the low of mathematics problem-solving ability of Indonesian students. Furthermore, it is important for mathematics teachers to consider and evaluate mathematics learning process due to the low result of Indonesian students regarding with problem-solving ability.

The low result of students' problem-solving ability is caused and affected by many factors. Heong said that weakness in understanding concepts, logic-thinking and lacking strategic knowledge caused errors in problem-solving [5]. Also, Johan stated that many students could not bring meaning to the problems and did not know how to plan and perform the problem-solving strategies [5]. Mathematics learning process in Indonesia was still mechanistic, that teachers explained formulas, algorithms, examples, and then students did the exercise according to the example provided by the teacher [6]. Those opinions above indicate that mathematics learning process still tends to be seen as a process of cognition that promotes students' rote related to concepts, formulas, and strategies. Furthermore, it leads students to have no deep understanding the concept, formula, strategy, and the overall material. The learning process also can cause the lack of meaningfulness of knowledge learned by students.

Problem-solving activity in mathematics learning process does not only relate to the knowledge and procedure involved students' cognition operation. It also requires the thinking awareness of students for controlling and regulating their thinking process. Risnanosanti stated that problem-solving was a complex process involved metacognition [7]. It is also relevant to the Stenberg statement said that students needed metacognition skill, in addition to cognitive component, to regulate and monitor the problem-solving process [8]. Thus, metacognition process is required for students in solving mathematics problem to improve problem-solving ability.

According to Flavell metacognition can be defined as an individual's knowledge about his/her cognitive processes [9]. On the other hand, Brown defined metacognition as students' awareness and organization of thinking processes that they use in planned learning and problem-solving situations [10]. In addition, Swanson defined metacognition for learning process context as individuals' awareness of their ability to monitor, regulate and control their own activities [10]. Ozsoy stated that metacognition involved awareness regarding the learning process, planning, choosing a strategy, monitoring learning process, to be able to correct one's own mistakes, to be able to check whether the strategies used is useful or not, to able to change the learning method or strategy when necessary [11]. Thus, metacognition can be defined as individual's awareness and understanding regarding his/her cognition process and the ability to control and regulate the cognition process.

Anggo [12] stated, *"the metacognition process is the self-awareness and self-regulation of thinking during solving problems activity"*. Schoenfeld specifically stated that metacognitive processes included assessing one's own knowledge, formulating a

plan of attack, selecting strategies, and monitoring and evaluating progress [13]. Thus, metacognition process involves awareness and reflection regarding individual's knowledge of cognition and regulation of cognition process. Metacognition process can be defined as a process involved awareness of thinking in using and optimizing individual's knowledge of cognition through regulation of the cognition process.

It can be concluded that metacognition process in problem-solving relates to students' awareness of thinking to regulate and control their cognition activity. Therefore, metacognition process can be identified through three aspects namely *planning*, *monitoring*, and *evaluation* [12,14]. Rozen and Kramarski explained that *planning* involved activities for identifying information, knowledge, and many possible strategies could help students in solving the given problem [14]. *Monitoring* related to students' awareness regarding their understanding and quality of work during solving the given problem, while *evaluation* related to students' activities to recheck the problem-solving activity [14].

Based on opinions above seems that there is a strong relationship between metacognition process and problem-solving activity. Krulik and Rudnick stated that problem-solving as a process in which an individual uses previously acquired knowledge, skills, and understanding to find the solution [15] usually involves many systematics steps. One of the most using steps in mathematics problem solving is Polya's steps. Polya's steps in solving problem involve four steps namely *understanding the problem*, *devising a plan*, *carrying out the plan,* and *looking back* [16,17]. It is considered as simple steps for helping students to find the solution to the given problem. Therefore, it is important to analyze and investigate whether the metacognition process is identified in all steps of problem-solving. Specifically, it is required further research regarding the exploration on the analyzing and description of metacognition process in Polya's steps of problem-solving.

Students' success in solving mathematics problem is also influenced by the affective factor like mathematics anxiety. Richardson and Suinn [18] defined mathematics anxiety as *"a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations"*. The high level of mathematics anxiety interferes with students thinking process in solving the mathematics problem. Kurniawati and Siswono showed that there was a negative effect given by mathematics anxiety and self-efficacy towards students' mathematics problem-solving ability [19]. In addition, Altun stated that the high level of mathematics anxiety during solving mathematics problem could make students difficult and fail to find the solution [20].

Based on the explanation above, both metacognition process and mathematics anxiety are essential component and factor in mathematics problem-solving activity. Many types of research have been conducted to find out the relationship between students' metacognition and mathematics anxiety in mathematics problem-solving. Legg and Locker found that metacognition can reduce the negative effect of mathematics anxiety regarding mathematics skill [21]. The research of Alikamar, et al.

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concluded that students with high metacognition were able to control mathematics anxiety, so they can work optimally in solving mathematics problem [22].

Many types of research explained above have been showing the relationship between metacognition and mathematics anxiety. Unfortunately, there are still few types of research regarding the exploration of metacognition process in solving mathematics problem of students with high mathematics anxiety. Therefore, this present research aims to analyze and describe metacognition process of students with high mathematics anxiety in solving mathematics problems. It focuses on analyzing the metacognition process of students with high mathematics anxiety based on Polya's problem solving phases.

2. Method

This research is descriptive analysis research using a qualitative method with case study strategy. Qualitative research was a research aimed to understand phenomena regarding subject's experience holistically through the description in the form of word and language [23]. Yin [24] defined case study as, "*an empirical inquiry that investigates a contemporary phenomenon within its real-life context*". Thus, qualitative research with case study strategy is research aimed to investigate and understand in deep and holistically contextual phenomena experienced by the subject. In this research, the contextual phenomena are metacognition process of students with high mathematics anxiety in solving mathematics problem.

It was held at SMPN in Surakarta, Indonesia since February until April 2017. The subjects in this research involve eight students of 7^{th} grade chosen with purposive sampling. The subjects in this research have a high mathematics anxiety level and considered to be able to communicate their idea or thinking process while solving the given problem.

Data in this research is in the form of the video record of mathematics-task based interview. The video record was also transcribed by the researcher to help for analyzing process. The result of the interview was used to obtain information of subjects' metacognition process while solving the mathematics problem. Before subjects were interviewed, the researcher asked the students to complete *Mathematics Anxiety Scale* (MAS) to obtain information about students' mathematics anxiety level. The instruments in this research namely MAS, Mathematics Problem-Solving Task (MPST), and guidance interview were validated by three expert validators for each instrument. In addition, before using MAS, researcher tested for trial the instrument on 60 students to measure items internal consistency and the reliability. The results of MAS trials showed the internal consistency index of items $r_{XY} \geq 0.3$ with reliability coefficient $r_{11} = 0.92$.

Data collecting to obtain the information about students' metacognition process was done two times for each subject. In the first step, subject was asked to solve MPST 1 involve a mathematics problem about sets material, while researcher also conducted the interview during problem-solving activity. Second step for collecting the data was done with the same procedure to the first step using MPST 2. After that, researcher analyzed the findings qualitatively to describe subjects' metacognition process in solving mathematics problem. Data were analyzed with Miles and Huberman steps of analyzing involve data reduction, data display, and verification [25].

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3. Result and Discussion

Table 1 describes the result of mathematics anxiety scale for the research subjects that involve eight students of 7^{th} grade in SMPN 16 Surakarta, Indonesia. It describes subjects' MAS score and mathematics anxiety level. Based on the result in Table 1 seems that all subjects were identified in the high level of mathematics anxiety with the MAS score $\bar{x} \geq 56$. In addition, the subjects also were considered to be able to communicate their own idea and thinking process during solving mathematics problem.

Table 1. Description of Subjects' Mathematics Anxiety Level

Subject	MAS Score	MA Level
SPL1	62	High
SPL2	61	High
SPL3	61	High
SPL4	60	High
SPP1	62	High
SPP2	61	High
SPP3	60	High
SPP4	57	High

After selecting the subjects, the researcher gave them mathematics problem-solving task involve MPST1 and MPST2. The subjects were asked to solve the problem in different time and the researcher interviewed them while solving the problem. The result of interview taken by the researcher involve mathematics-task based interview for step 1 and step 2. Based on the interview result for all the subjects either in step 1 or step 2, it can be described the summary of metacognition process for each Polya's problem solving step as follow.

3.1. Step of Understanding the Problem

In this step, it was identified all aspects of metacognition process *planning*, *monitoring*, and *evaluation*. One of the results of subject's problem-solving task regarding understanding of the problem is shown in Figure 1. Based on the results of problem-solving task seems that the subjects understand the problem. Also, the subjects can identify the information contain in the given problem. Furthermore, subject realize about the importance of representing the problem. It is also relevant to the the result of the interview as shown in Table 2. It seems that the metacognition process of students with high mathematics anxiety in solving mathematics problem involves all three aspects *planning*, *monitoring*, and *evaluation*.

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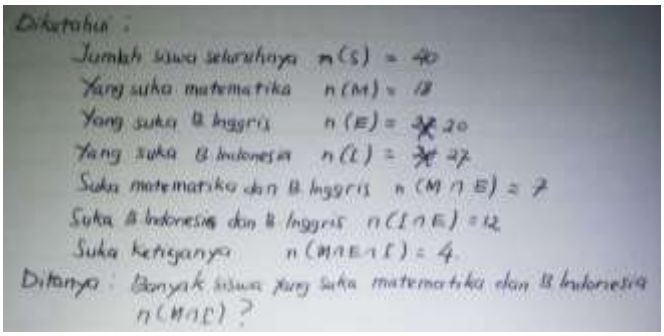

Figure 1. Subject's problem-solving result in understanding the problem

In this step of problem-solving, subjects used the metacognition process on *planning*. Subjects were aware of the importance of understanding the given problem. It was indicated by subjects' activity to read the given problem more than once. Subjects were also aware of the importance of representing the problem for helping them to find the solution. It was indicated from students thinking awareness to identify and write information on the problem. In addition, subjects also can identify and know about the unknown in the problem. It means that subject aware about the aim of problem-solving activity. Thus, subject used their metacognition process regarding *planning* aspect to explore and understand the information of the given problem.

The subject also was able to optimize their metacognition process regarding *monitoring* aspect. It was indicated from subjects' awareness about the relation of given problem with mathematics material and knowledge has been studied before. The subject could identify that the given problem related to sets material. Subject also stated that they had been ever found and solve the relevant problem even it was not really same. In addition, subject also can identify weather information identified before was right or wrong. Subjects also can identify mistakes or incompleteness regarding the identified information. Thus, subject used their metacognition process regarding *monitoring* aspect to explore and understand the information of the given problem.

Metacognition process regarding *evaluation* aspect also was identified in this first step of problem solving. It involved subjects' awareness to recheck their understanding of the given problem. It is indicated by the subjects' activity to evaluate the relevance of identified information with the given problem. In addition, subject aware about the importance of evaluating the representation of the given problem. It was indicated from subject activity to recheck weather the representation was right or not, before solving the problem. Thus, subject used their metacognition process regarding *evaluation* aspect to explore and understand the information of the given problem.

Table 2. Description of MPST Based Interview in Polya's First Step

Metacognition Process	Description
Planning	Subjects aware about the importance of understanding the given problem. Subjects also aware about the importance of representing the problem

	for helping them to find the solution. Subjects also can identify and know about the unknown in the problem. It means that subject aware about the aim of problem solving activity.
Monitoring	Subjects aware about the relation of given problem with mathematics material and knowledge have been studied before. Subject aware whether the information identified before was right or wrong. Subjects also can identify mistakes or incompleteness regarding the identified information.
Evaluation	Subjects aware about the importance of rechecking their understanding of the problem. Subject aware about the importance of evaluating the representation of the given problem. Subject aware about the sufficiency of the information to find the solution.

3.2. Step of Devising a Plan

In this step, subjects' metacognition process involved only planning and monitoring aspect, while evaluation aspect was not identified. One of the results of subject's problem-solving task regarding devising a plan is shown in Figure 2. Based on the figure seems that subject can identify one of the possible strategy. Subject use diagram Venn for solving the problem. It is also indicated that subject realize about the relevance of using diagram Venn to solve the given problem. The results of interview also show the same thing. The metacognition process for each identified aspect is described in Table 3.

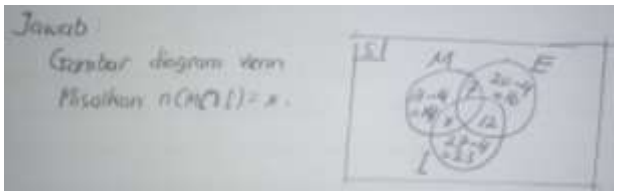

Figure 2. Subject's problem-solving result in devising a plan

In devising a plan, the subject used metacognition process on planning aspect. Subjects are able to identify possible problem-solving strategy that is using Venn diagram or formula. In addition, subject was also able to predict the problem-solving procedures related to the using strategy either Venn diagram or using the formula. It indicates that subject used metacognition process regarding planning aspect to identify possible strategy and procedure for solving the problem.

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Table 3. Description of MPST Based Interview in Polya's Second Step

Metacognition Process	Description
Planning	Subject could identify many possible strategies for solving the problem. Subject could choose the appropriate strategy to use based on their prior knowledge. Subject understand and able to identify the procedure for solving problem using the chosen strategy.
Monitoring	Subject aware and able to identify the relevance of the problem with the strategy planned to use. Subject aware weather the strategy and procedure planned to use could help for solving the problem based on their own experience and prior knowledge. Subjects also know the advantages of the strategy planned to use.

Subjects are also able to use the metacognition process on the *monitoring* aspect in identifying the strategy. It was indicated from subject awareness in linking the use of strategy to other relevant problem. Subject also stated that the strategy planned to use could help them to find the solution. It was considered by the subject due to their own prior knowledge and experience in using either Venn diagram or formula to solve the other relevant problem. Subject also could identify the advantages and main reason for using any strategy in solving the problem. Many students stated that using Venn diagram is simpler than formulas. On the other hand, many other stated that using Venn diagram is more difficult relate to the construction of Venn diagram based on the information on the given problem. Thus, subject used metacognition process regarding *monitoring* aspect to identify possible strategy and procedure for solving the problem.

Unfortunately, in this Polya's step it was not identified subjects' metacognition process in evaluation aspect. The subject did not recheck or reflect on the correctness of the developed problem-solving plan.

3.3. Step of Carrying Out the Plan

In this step, it was identified only planning aspect of student's metacognition process. One of the results of subject's problem-solving task regarding carrying out the plan is shown in Figure 3. Based on the figure seems that subject can use the strategy. In this case, the subject knows how to use diagram Venn for solving the problem. It is indicated by students result to draw diagram Venn and use it for evaluating x value. On the other hand, subject doesn't realize that the figure is not correct and procedure also for evaluating x is wrong. In this case subject doesn't realize about the mistakes and cannot identify or evaluate the mistakes.

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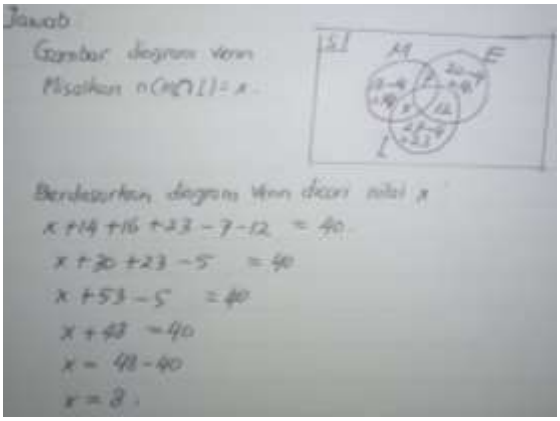

Figure 3. *Subject's problem-solving result in carrying out the plan*

The results of interview also show the same thing. The result of the interview showed the metacognition process as described in Table 4.

Table 4. Description of MPST Based Interview in Polya's Third Step

Metacognition Process	Description
Planning	Subject aware and know how to use the strategy to solve the problem. Subject used the strategy to find the solution. Subject used appropriate procedure to find the unknown based on the strategy.

In this step of problem-solving, subjects' metacognition process involved only the *planning* aspect. Subject used the metacognition process regarding *planning* aspect to carrying out the problem-solving plan previously thought out. It was indicated from subject awareness to use a strategy (either Venn diagram or formula). In addition, subject also used the strategy by drawing a Venn diagram or writing the formula based on information that has been identified. Subjects also perform calculations based on the Venn diagram or formula. It means that, subjects were able to use their awareness of thinking on planning to use a strategy and procedure for solving the problem. Thus, it can be concluded that subject used metacognition process regarding *planning* aspect to use the strategy and procedures for finding the solution of the problem.

However, in this step the metacognition process regarding with *monitoring* aspect was not identified. Subject did not aware about the correctness of the strategy and procedure. Subject could not identify any mistakes on Venn diagram, formula errors, or calculation errors. Subject did not aware about the relevance of Venn diagram or formula with the information which has been identified. So even with the *evaluation* aspect, the subject did not recheck or evaluate the problem-solving process. Subject also

did not recheck weather Venn diagram drawing (or formula written) by subject was right or not. The calculation for finding the unknown also was not evaluated by the subject. Subject stated that the problem-solving activity was finished when they find the solution (without checking whether the solution was right or not).

3.4. Step of Looking Back

In this final step of problem solving, subject did not use their metacognition process either in *planning, monitoring,* or *evaluation* aspect. Subject did not use the metacognition process for evaluating the whole problem-solving activity. It was indicated from the findings that the subject did not aware about the importance of recheck the problem-solving process that has been done from the beginning until find the solution. The subject stated that after finding results based on the strategies and procedures performed there is nothing to do anymore. As a result, the subject could not identify the various mistakes made. In addition, subject could not correct the mistakes made and could not identify weather the result or solution have been really solve the problem or not.

Based on the results explained above seems that students' metacognition process during solving mathematics problem is not optimal in all steps. In the first step students may able to use their metacognition process, but it was not optimal for three next steps. In fact, in the last step students do not use their metacognition process at all. It is same with du Toit and du Toit [26] research that there were no metacognitive behaviors that identified in Polya's fourth phase. In addition, the results explained above also indicates that the high of mathematics anxiety affect students' metacognition process during solving mathematics problem. As Beilock and Car [21] stated that anxiety could tax students working memory to such an extent that students with high aptitude would begin performing poorly. Everson, et al. also stated that when anxiety was high, metacognition had more of a negative impact and thus resulted in poorer performance [21]. Thus, it can be said that students with high mathematics anxiety cannot used their metacognition process optimally. The high of anxiety lead students to the condition that they are not aware about the importance of regulating and controlling their cognition activity.

4. Conclusion

Based on the results and discussion it can be concluded that generally the metacognition process of students with high mathematical anxiety in solving mathematical problems has not progressed optimally. In the problem-solving step of *understanding the problem*, subjects use metacognition processes in all three aspects of *planning, monitoring,* and *evaluation* to identify the information contained in the given problem. In *devising a plan*, subjects' metacognition process was only identified in *planning* and *monitoring* aspects to explore many possible problem-solving strategies. In the problem-solving step of *carrying out the plan*, the subjects' metacognition process only involved *planning* aspect to apply the strategy and procedure chosen for finding the

solution. In the final step of *looking back*, subjects' metacognition process was not identified for all three aspects.

It shows that high mathematics anxiety can cause of students' metacognition process in solving mathematics problems to be not optimal. Furthermore, this condition leads the students to the lack of mathematics problem solving abilities. Therefore, it is really important for mathematics educators to consider and pay more attention toward students' mathematics anxiety and metacognition processes in designing better mathematics learning. Selection of models, methods, strategies, and media of mathematics learning is expected to be able to reduce the level of mathematics anxiety as well as optimize the students' process of metacognition.

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