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Metacognitive Skills of Male Students with Field Independent Cognitive Style in Problem Solving

Pathuddi
Universitas Tadulako
Palu, Indonesia
pathuddin@untad.ac.id

I Ketut Budayasa
Surabaya State University
Surabaya, Indonesia
ketutbudayasa@yahoo.com

Agung Lukito
Surabaya State University
Surabaya, Indonesia
gunglukito@yahoo.com

***Abstract*—This study aims at exploring the metacognitive skills of male students with a field-independent cognitive style in solving the problem. The main data was collected through the student-written works and in-depth interviews. To achieve this purpose, there were several procedures established in analyzing the data related to metacognitive skills. Data analysis is done through data reduction, data presentation, data interpretation and conclusion drawing. From the qualitative data analysis, we found that during the problem-solving process this subject has shown the metacognitive skills including planning, monitoring, and evaluating.**

Keywords—metacognitive skills, male, cognitive style, field independent, problem-solving

I. INTRODUCTION

The objective of instructional teaching one-variable limit expectedly covers: Students are able to understand how one-variable limit function contributes to science and its advantages upon other learning materials, especially differential; Students are able to understand the use of one-variable limit concept to investigate, interpret, and make a decision related to either calculus or applied problems; Students are able to understand how one-variable limit as basic concept could contribute to other courses such as calculus II or advanced calculus; Students are able to understand how to communicate the one-variable limit concept, especially its function in basic science [1]. It is a very high demand that can not be achieved only through learning that emphasizes rote learning, routine work-out exercises, commonly used in conventional learning. One way of learning that can meet that goal is learning problem-solving by involving metacognition [2], [3].

Metacognition is an aspect of critical thinking that includes students' ability to develop a systematic way of solving problems and to imagine and evaluate the productivity of thought processes. Flavell states that metacognition consists of metacognitive knowledge and metacognitive experience or regulation [4]–[6]. Moreover, Brown also divides metacognition into knowledge about cognition and regulation of cognition [3, 5].

Metacognition in education has been widely used to optimize learner's competence in solving problems [7]–[10], to understand the content of readings [11], to optimize learning achievement [12], and metacognition can lead to more active learning [13], Students, whose metacognition is high and who have critical thinking and are well-creative, will be at easy to learn and understand various concepts or materials expansively [14], [15]. Metacognition was an essential element underlying student thinking skills and conceptual understanding [16], [17]. Principally, attempt to include metacognition into various learning activities expectedly offers immense advantages to enhance learning quality

In a simply superficial definition, metacognition means thinking about thinking or cognition about cognition [5], [12], [18], [19]. There are numerous definitions regarding the metacognition developed in the cognitive psychology field, one of which is Flavell's definition, stating that metacognition is competence to understand and monitor an individual's thinking, assumption as well as its implication [20], [21]. This notion emphasizes on understanding and monitoring an individual's thinking; therefore, the process of metacognition differs in each person depending on its competence.

From elaborated definitions above, metacognition in this study refers to awareness and control or regulation of one's cognitive process. Therefore, there are two important aspects of metacognition, which are: awareness about cognition; and control or regulation of cognition processes during the learning process of understanding the concept of one-variable limit. The cognitive awareness, in this case, covers the assessment of defined and undefined things. It also refers to the method used to set the cognitive process. Meanwhile, the control of cognition refers to directing, planning, and monitoring cognitive activities while understanding the concept of one-variable limit.

Besides that, there are four important components of metacognition, which are: planning, monitoring, evaluating, and revising. These four components are elaborated as follows: (1) Planning refers to intentional activities which organize the learning process. The attitude in this phase consists of defining learning objectives, learning arrangement, learning strategies, and learning time allocation; (2) Monitoring refers to particular activities which direct serial learning progresses, for example, the learner could query himself "what am I learning? Or am I on the right track?", etc. Monitoring itself must be particularly set during learning activities; (3) Evaluating learning process covers the measurement of learning progress achieved during learning activities. This evaluation systematically helps learner by developing several competencies and strategies necessarily needed to gain a new applicative situation; (4) Revising learning process includes the modification of previous plan by highlighting on learning objectives, learning strategies, and learning approach [2], [21].

Meanwhile, Brown [21] defines metacognition as an awareness of an individual's thinking activities; a method

used to set one's cognition process; and self-control on how to direct, plan, and monitor cognitive activities. This definition highlights awareness of cognitive activities. In this case, metacognition relates to how an individual is fully aware of the thinking process. This such awareness will be realized through the way individual sets and organizes his thinking activities.

Affirms that metacognition refers to awareness and monitoring of one's own cognitive system and the functioning of the system [22]. This definition has likely combined two previous definitions Flavell's definition and Brown's definition which point out that metacognition refers to awareness and monitoring of one's cognitive system and how the system functions as what is expected.

Problem-solving is one of the appropriate methods to teach mathematics. An individual with high competence in solving the problem will draw many benefits such as: developing critical thinking and strengthening mathematic competences. There are four categories in using the problem-solving method: generally developing cognitive competence, encouraging creativity, providing applicative mathematics, and motivating the learner to learn mathematics life [2], [3], [23], [24].

By possessing problem-solving competence gained from mathematics learning, it is expected for learners to be able to solve any problems in their daily life [3], [23]. Teaching problem-solving competence to learners will surely enhance their analytical thinking in making a decision.

During solving problem, each individual has a particular characteristic which differs from each other. Hence, it can be said that an individual differs from one another. Besides teaching problem-solving, teachers should also concern on learner's cognitive style. The cognitive style can be potentially used to increase learning efficacy. There are two cognitive styles distinguishing an individual's characteristic, which are: field-independent and field-dependent cognitive styles [25], [26].

These two cognitive styles differ one another yet could not be said that learner with field-independent cognitive is better than learner with field-dependent cognitive style and vice versa. An individual with analytical characteristic (known as field-independent cognitive style) will classify the surrounding environment into several components and be less dependent or less influenced by the environment. Meanwhile, an individual with a global characteristic (known as field-dependent cognitive style) will focus on the holistic environment and be dominated or influenced by the environment [25]–[28]. Based on the description, the aims of this study at describing the metacognitive skill of male students with a field-independent cognitive style in solving the problem.

II. METHOD

The study was a descriptive study with a qualitative approach which intentionally aimed to encompass metacognitive activity of a prospective male teacher with field-independent cognitive style in solving the problem.

This study was conducted at the Department of Mathematics and Science Education, Faculty of Teacher Training and Education of Tadulako University. Specifically, it investigated a student who had passed calculus course and therefore presumably possessed proper knowledge about the concept of limit.

There were several procedures established as follows: (a) initial phase, selecting subject ff male students who has field-independent cognitive style by utilizing particular criteria; (b) second phase, arranging problem-solving assignment of limit function which has been confirmed by experts; (c) third phase, conducting unstructured interview to verify the data from the assignment; (d) fourth phase, recording and taking field note. It was intended to collect all information during the interview; and (e) the fifth phase, analyzing the data related to metacognition profile in solving limit problem done by subject [29].

The main instrument is the researcher's own research and auxiliary instruments, which tests cognitive style, problem-solving task limit and guide the interview. Cognitive style instrument used is called the Group Embedded Figures Test (GEFT) [25]–[28]. Problem-solving task limit used is a matter of limit functions of one variable, is as follows: Determine the value of and if we have the following $f: \boldsymbol{R} \to \boldsymbol{R}$ with:

$$f(x) = \begin{cases} x^2, & x < 0 \\ 1, & x = 0 \\ x, & 0 < x < 1 \\ 1 - x^2, & x \geq 1 \end{cases} \tag{1}$$

III. RESULTS AND DISCUSSION

The subjects in the study were given a code S, and researchers were coded P. The code number indicates the sequence of stages of the interview (e.g. (010)S : this means that subject S was tenth in the interview sequence).

The male students with field-independent cognitive style are symbolized with 'S.' As interviewed, S conveyed the facts derived from the problem in a complete and sequential way. In understanding the problem, S realized that in order to solve the problem, He had to understand it in the first place by reading. When was asked about him certainty in understanding the problem with such way, S convinced that with a well-planned method, He would understand the problem well. Therefore, S realized that to understand the problem well; He planned a method of silent reading by pointing the text using a pen, and thus He could manage the steps to solve the problem [22]. In understanding the given problem, S occasionally looked at the task in order to recall what He knew and to understand what was asked and therefore He became more focused on solving the problem.

(002)P : What do you plan to do?

(002)S : *I think I should read it first*

(003)P : For what?

(003)S : *To grasp the matter and understand it, Sir.*

(004)P : Are you sure?

(004)S : (S looks back at the text and then said)
Yes Sir

(005)P : How do you do that?

(005)S : *Reading it inwardly to understand*

After reading the text, S acquired the information that what had defined in the task was the function of f which

maps the set of real numbers to another set where f(x) equals x2 if x is less than 0, equals 1 if x is as equal as 1, equals x if less than 1 and more than 0, and equals if x is more than or as equal as, while what had been questioned was limit value of f(x) for x approaching 0 and limit value of f(x) for x approaching 1.

Therefore, S figured out what He knew and realized what He needed to understand the problem. Based on the interview data, S attempted to make a problem representation in the form of function graphs by drawing each of the function graphs and combining them into a single picture (Figure1). Therefore, S realized that it was important to draw the function graph and rearranged the problem with his own words or in a different form. S had already rechecked the steps He took in understanding the problem, where He concluded that He had already understood the problems by stating that all the information provided in the task was clear and He did not think another way to understand the problem due to his opinion that in order to understand the problem, all He needed were the chance of reading, writing, and drawing the graph function.

After comprehending the problem, S planned to devise a plan of problem-solving by using a method. He convinced that He could arrange a solution by using a certain strategy to reach the cognitive goal since He had already studied about the limit in a calculus course. Therefore, S predicted that He was capable of recalling the information stored in his long-term memory.

(a)

(b)

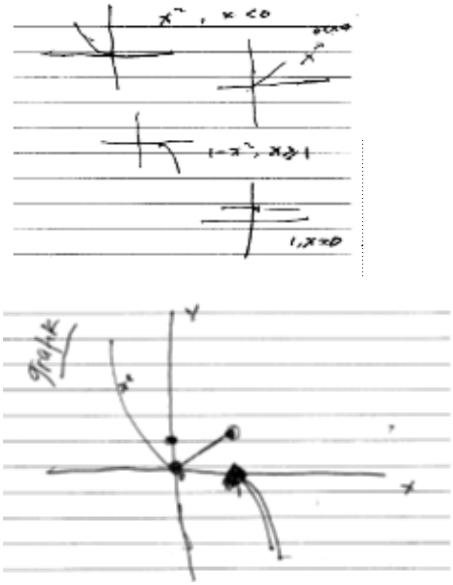


Fig. 1. (a) The handwriting S draw the graph of each function given, (b) The handwriting S combines graph of each function given

(038)P : Approximately how much time do you need to make a plan for solving this problem?

(038)S : *About 9 minutes, Sir*

(039)P : Are you sure you can complete it within 9 minutes?

(039)S : (S bowed the head)

Yes sir, because I've studied the limit function

(040)P : What is your plan?

(040)S : *I plan to solve it by using the definition and the theorem of limit, Sir*

(041)P : Why do you use that?

(041)S : *To make it easier. Such a question usually uses the definition and the theorem of limit*

Based on the interview data, S predicted that the amount of time He needed to arrange an approach or strategy in solving the problem was approximately 9 minutes. He was able to arrange the plan because He had already experienced in finishing a task regarding the function of limit. In solving the problem, S planned to use the definition of left and right limit and also the theorem of limit (Figure 2). Such cognitive strategy was chosen by him in order to solve the problem easier.

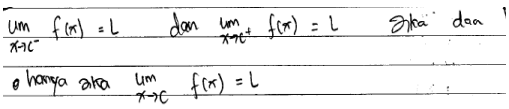


Fig. 2. The handwriting S in writing the theorem will he use

In order to reach the cognitive goal, S planned to decide the value of the limit by determining the values of the left and the right limit. He figured out that the limit value of a function on a point was not always available and highly dependent on the value of the left and the right limit. He realized that He had to evaluate the plan. He rechecked the plan to know whether it corresponded with the expected result and also evaluated the relevancy of the procedure. He planned as the basic assumption that the cognitive goal had already achieved. Thus, He could claim that the plan was useful to solve the problem and stated that there might be another way, but that was the only way He had in mind.

(057)P : What else will you do next?

(057)S : *I will solve the problem according to the previous plan, Sir*

(058)P : How much time do you need to execute the plan ?

(058)S : *About 15 minutes, Sir*

(059)P : Will it be completed for 15 minutes?

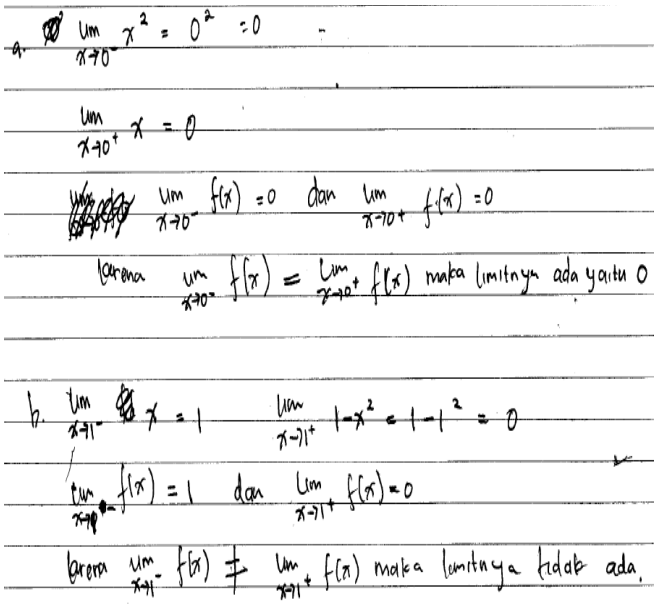
(059)S : (S bowed the head).

I hope, Sire

(060)P : Are you sure?

1(060)S : *Yes, I'm sure since I have explained the steps before.*

Based on the interview data, After finishing the step of devising a plan, S was about to realize what He had planned. In the beginning, He predicted that He could finish the task according to plan. Based on the interview data, He predicted that the amount of time He needed to execute the plan was 15 minutes. At the first moment, He seemed to doubt about finishing the task in 15 minutes. After taking a moment of bowing and thinking, He seemed confident to finish the task in the given time over the reason that all the steps He took were clear and well planned. From the data, S figured out that He could finish the task with the help of his previously-planned steps and also realized the importance of predicting a time in executing the plan of solving the problem [2], [21], [23].



(065)P : Now I want to ask you about what you have done. Ready?

(065)S : *Yes, Sir.*

(066)P : What did you think about before you finished the problem?

(066)S : *Thinking to solve the problem in accordance with what has been planned*

(067)P : In implementing the plan, what did you do first?

(067)S : *First, I wrote down what was known and what was asked*

(068)P : And then?

(068)S : *Trying to remember what I was going to use sir*

(069)P : What do you mean?

(069)S : *I mean the properties or theorems used in solving the problem, Sir.*

(070)P : Then, what else?

(070)S : *Next, I drew known function graphs*

1(071)P : For what?

(071)S : *To make it easier in testing whether the left limit and right limit is correct or not*

Based on the interview data, S planned to solve the problems based on the steps He had arranged. Before solving it, He reconsidered what would He do in the first place. Firstly, He wrote everything He knew and things that were asked, recalled the principles or theorems that were going to be used, and drew the defined function graphs. Therefore, it can be concluded that He has already possessed the awareness that it is important to recall critical information during the execution of the plan. Furthermore, He monitored the execution of problem-solving with the awareness toward his metacognition insight during the step of problem-solving, where He executed the steps in detail and systematically.

According to the interview data, along with the awareness on procedural knowledge, S presented his thought by realizing that a function could have a limit if it had the left and the right limit with the same value and value of the function on a certain point was not always equal with function value. In solving the problem, He used the right procedure of calculation to get the left and the right value and explained sensible reason on each step of getting the goal of problem-solving.

S realized to evaluate the problem-solving He executed. He rechecked the result to find it fit with expectation, attempted to see the probability of a fault in the calculation, and evaluated the suitability of procedure that He had planned as the reason to conclude that the cognitive goal had been achieved. Therefore, He could state that the execution of problem-solving on limit had met the task goal and there might be another way to solve the problem, but that was the only way He understood.

After S executed the plan, He revealed the fact that He built his mental representation by rechecking the result, starting with the steps of solving, recalling what He knew, what was questioned, and what limit theorems were used to determine the limit value. He predicted that it required 5 minutes to recheck based on rational consideration that He would check the compatibility between the plan and the execution by rechecking them one by one, line by line. With awareness on his metacognitive knowledge, He rechecked the steps of the procedure in solving the limit problem in detail and systematically [2], [12], [21], [23], [30].

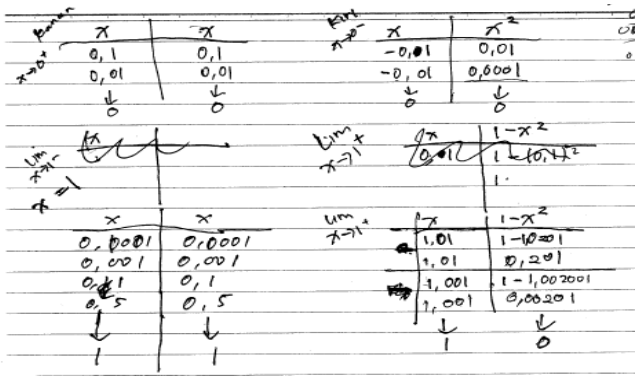


Fig. 3. The handwriting S to check the results obtained

Based on the interview data, regarding his awareness, S evaluated the result of the rechecking on the execution of limit problem-solving and convinced that He had already finished it by using the correct procedure. He took several numbers in a range of 0 and 1 and then made sure that the calculation function value was correct, and the new result matched the previous one (Figure 3).

IV. Conclusion

According to what has been stated above, we found that during the problem-solving process this subject has shown the metacognitive skills including planning, monitoring, and evaluating as well as the metacognitive knowledge that is, either in the form of declarative knowledge, procedural knowledge, and conditional knowledge. These metacognitive activities emerged in all the phases of understanding the problem, devising a plan, carrying out the plan, and looking back.

Based on the data of metacognitive activity of prospective male teacher in solving the limit problem above, lecturers and educators are suggested to develop a learning model and device to encourage learners to involve metacognition in solving a limit problem.

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