Metacognitive activity of male students: difference field independent-dependent cognitive style

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Abstract. The study aimed to explore the metacognitive activities of male students who were independent field cognitive style and field dependent cognitive style in solving problems. The type of this research is explorative with qualitative approach, that is from written works and in-depth interviews. Data analysis is done through data reduction, data presentation, data interpretation and conclusion drawing. The results showed that male students with field independent cognitive style, had a tendency to be structured, well organized in solving problems, could restructure new information and relate it to the knowledge they had. While male students with field dependent cognitive style, they had characteristics in solving problems are unstructured and not well organized. Also, they’re difficult to restructure new information and relate it to the knowledge they have.

1. Introduction

Metacognition is the ability of self-knowledge-monitoring. Metacognition also has functions of controlling and controlling the process of taking logical conclusions and information that processes in one's memory system. While monitoring refers to the way we evaluate what we already know or do not know. Metacognition can also be interpreted as advanced thinking which involves active control of cognitive processes [1,2,3]

Metacognition is widely used, among others related to efforts in optimizing the ability of students in solving problems [4, 5, 6, 7], optimizing learning outcomes that can be achieved by students [6, 8, 9], understanding the contents of a reading topic [10, 11, 12], or improving someone's abilities to become a successful learner [13, 14]. Therefore, the efforts that involve metacognition in various learning activities are expected to provide benefits to improve the quality of learning being implemented.

Metacognition as a thought is about thinking itself which is the interaction between three important aspects which are: 1). knowledge of the self-thinking process, 2) control or self-regulation, and 3). beliefs and intuition. Knowledge of thinking processes concerns how accurate a person is in expressing their thinking processes, self-awareness or self-regulation, the accuracy of a person in maintaining and managing what they must do when it comes to solving mathematical problems, and how accurately someone in using input from his/her observations to direct activities to solve problems, whereas beliefs and intuitions concern any mathematical ideas that are prepared to solve mathematical problems and how those ideas form ways to solve math problems [4, 7, 15].

Metacognitive skills are a control of their own thinking processes that are distinguished in prediction skills, for example "how difficult is a task", planning skills, for example "what will I do to complete this task?", Monitoring skills, for example "Have I not known all this time that I have gotten to achieve the goal?" And evaluation skills, for example "are all the tables that I have made complete for problem solving"? [2, 16, 17]

The components of metacognition are based on the activities carried out by students on problem solving, consisting of: planning, monitoring and reflection. While Brown and Kirsh group metacognition by linking with learning activities or the educational process. Although various metacognition groupings that have been presented in passing appear to be different, in general these groupings have strong links [2, 18]

The components of metacognition are: (1) Planning refers to deliberate activities governing the entire learning process. Behavior in this planning consists of setting learning goals, learning sequences,
learning strategies, and estimating expected learning time. (2) Monitoring relates to directing the progress of learning. For example, students can ask themselves like "what I do", "am I on the right path", "how should I do it", "should I finish it differently" and so on. Monitoring activities are arranged typically throughout learning activities (3) Evaluating the process of self-learning includes assessing the progress achieved in learning activities. This systematic evaluation method can help students by developing a set of skills and strategies needed from what they can get in new situations where they can applied [19].

Problem solving is one of the proper methods for learning and teaching mathematics. A person with problem-solving skills has several advantages, including developing critical thinking skills and strengthening math skills. There are four categories in teaching problem solving, namely: solving the problem develops cognitive skills in general, problem solving encourages creativity, problem solving is part of the mathematical application process, and problem solving motivates learners to learn math [7, 20]. With the ability to solve problems obtained from mathematics lessons, students are expected to use to solve problems in everyday life, as revealed by Cooney that is, teaching learners to solve problems, allows learners to be more analytical in making decisions in his/her life [17, 21].

Other than gender differences, cognitive styles differences can also influence the achievement of learning outcomes [19, 22, 23]. Women and men have different ways of using problem-solving strategies [22]. Gender factors in mathematics because of the biological differences in the brains of boys and girls, where in general girls are superior in the field of language and writing, while boys are superior in the field of mathematics better [22, 23]. Based on the description, the purpose of this study was to determine the profile of metacognitive activity of male students in solving mathematical problems in terms of cognitive style.

2. Method
This research is explorative type with qualitative approach. The subject is two student from Mathematics Education department, Faculty of Teacher Training and Education, Tadulako University. He is the student who have followed the calculus course, we assumed that he has adequate knowledge about the concept of limit of a function in one variable.

The data collection includes written assignment and in-depth, unstructured interview. For assuring credible data we utilized a time triangulation. To analyse the credible data we followed the Miles and Huberman model with stages: 1) data reduction, 2) data display, 3) conclusion drawing [24].

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 Group Embedded Figures Test (GEFT) [25, 26, 27]. Problem-solving task limit used is a matter of limit functions of one variable, is as follows.

\[
\lim_{x \rightarrow 0} f(x) = \begin{cases} 
 0, & x < 0 \\
 1, & x = 0 \\
 x, & 0 < x < 1 \\
 1 - x^2, & x \geq 1 
\end{cases}
\]

3. Results
In the following we label the subject of the research with \( S_i \) \((i = 1, 2)\) and the researcher with \( P \). The attached number string indicates the sequence of the interview stage (e.g. \((005)\) \( S \) means that the subject the respond is in fifth stage in the interview sequence).

3.1. Analysis of metacognitive activity of male students with independent field cognitive style \((S_1)\)

3.1.1. Phase of understanding the problems
In an effort to understand the limits of male students with independent field cognitive style \((S_1)\), plan to read the limit problem silently repeatedly so that they can get information about what is typed, during the interview \( S_1 \) infuses complete information, declare the problem in another form completely, re-
evaluate the graphic sketch that has been made and believe the results of the evaluation are correct. The explanation given by S1 can be known through the following interview transcripts.

(011)P : What you get?
(011)S1 : I got information about what was known and asked, Sir
(014)P : How do you get what you know and ask?
(014)S1 : By reading the questions carefully, I obtained information about what was known and asked about the problem Sir
(019)P : Are you sure that is what was asked?
(019)S1 : Yes Sir
(025)P : Then what else do you plan?
(025)S1 : I plan to sketch a graph of the functions known to, Sir
(030)P : Do you think the information in the question is complete?
(030)S1 : (S2 looks back at the question)
Yes, sir
(031)P : Do you think of other ways to understand the problem?
(031)S1 : No sir

3.1.2. Phase of devising a plan
Furthermore, when preparing a limit problem solving plan, male students with field independent cognitive style (S1) can express factual knowledge as detailed declarative knowledge, utilizing their declarative, procedural, and conditional knowledges, can explain the limit theorem used in detail so that no longer think of other ways in making plans and giving the right reasons. Subjects provide an explanation of the strategies used in solving problems, the subject is able to provide arguments that support his mind. The explanation given by S1 can be known through the following interview transcripts.

(040)P : That means?
(040)S1 : I will solve using the limit theorem, Sir
(041)P : Why are you using that?
(041)S1 : To be easier, Sir
(043)P : What is it like?
(043)S1 : \[ \lim_{x \to c} f(x) = L \]
Handwriting S1 writes the theorem that will be used
(057)P : You said earlier that you will plan. Is that enough?
(057)S1 : I think it's enough Sir
(061)P : Do you have other plans that can be used to solve the problem?
(061)S1 : There is no sir

3.1.3. Phase of carrying out the plan
When implementing a limit problem solving plan that has been prepared, male students with independent field cognitive style (S1) cannot estimate the time to implement the plan, but can review the plans that have been prepared before completing the limit problem completely, after completing and stated that he believed his work was right and did not think of other ways to solve the problem. The explanation given by S1 can be known through the following interview transcripts.

(063)P : After this what else will you do?
(063)S1 : Solve questions about, Sir
(064)P : How long do you think you are carrying out the plan?
(064)S1 : I can't estimate how long it will take
(065)P : I thought you explained the steps before?
(065)S1 : Yes Sir, but don't come later if I work I meet obstacles Sir
(066)P : So how are you?
(066)S1 : I just worked, Sir, according to what I had planned before
3.1.4. Phase of looking back

At the stage of checking the results of the limit problem solving that has been carried out, male teacher candidates with field independent cognitive style (S1) can re-examine the suitability of the plan with the results of the implementation of the plan completely and try to match the left limit and right limit obtained by others and explain it in full. The explanation given by S1 can be known through the following interview transcripts.

(067)P : Okay, you start working
(067)S1 : Iye I work sir
(068)P : Yes, please
(068)S1 : Yes, Sir

Handwriting S1 when solving problems

(069)P : Have you finished the commission?
(069)S1 : (S1 looks back at his job) Already Sir
(070)P : Can you challenge what you do?
(070)S1 : Yes, Sir
(071)P : Now you want to ask about what you are doing. Is it ready?
(071)S1 : Yes, is ready Sir
(073)P : In carrying out the plan first what did you do?
(073)S1 : I reread the matter about Pak and saw again what was known and what was asked, Sir
(074)P : Then, what else?
(074)S1 : Look back at the steps of the plan that I have arranged beforehand
(076)P : Then, what else?
(076)S1 : I also re-checked the chart of known function graphs
(102)P : Are there other ways you know?
(102)S1 : There is no more Sir, because I am sure my work is correct

(069)P : What else do you do?
(103)S1 : I plan to check what I have been working on, sir, especially the steps and results of the solution
(123)P : Why?
(123)S1 : I am sure that I am correct Sir, I have worked according to the correct procedure Sir and I took a number around 0 and 1 then I calculated the function value is correct, and the results are in accordance with the results I obtained before
(124)P : What else?
(124)S1 : (S1 looking back) That's all, Sir
3.2. Metacognitive activity analysis of male students with field dependent cognitive style (S₂)

3.2.1. Phase of understanding the problems
In understanding the problem of male students with field dependent cognitive style (S₂) reading the limit problem with a voice, conveying information incompletely and in an orderly manner, stating the problem in another form incompletely complete, re-evaluating the graphic sketch that has been made and sure the results of the evaluation are correct in the event that there are still errors and do not make improvements. The explanation given by S₂ can be known through the following interview transcripts.

(003)P : So what are your plans?
(003)S₂ : First of all, I have to read the problem slowly carefully, Sir
(011)P : Already?
(011)S₂ : (S₂ bowed head)
Yes, Sir
(013)P : So what do you get?
(013)S₂ : By reading I can find out what is known and what is being asked.
(015)P : How are you known and asked?
(015)S₂ : The only way is to read the question as a whole and understand it so that I can know what is known and what is being asked
(025)P : Can you explain what you wrote?
(025)S₂ : (S₂ look back at the writing)
Yes Sir
(028)P : So you understand?
(028)S₂ : (S₂ look back at what he wrote and then answer)
Just a little, Sir
(032)P : How do you plan?
(032)S₂ : Draw a graph of each function, Sir
(037)P : Why?
(037)S₂ : Because I have drawn each function according to the definition area given
(038)P : Do you understand?
(038)S₂ : (S₂ pay attention again)
Yes Sir
(040)P : Do you think of other ways to understand the problem?
(040)S₂ : (S₂ recheck the problem)
No, Sir

3.2.2. Phase of devising a plan
At the stage of drafting a male student's plan with a field dependent cognitive style (S₂) expressing factual knowledge as declarative knowledge, but incomplete, utilizing declarative, procedural, and conditional knowledge with but incomplete, can explain the limit theorem used, but less detailed and no longer think of other ways of making plans without proper reasons. The explanation given by S₂ can be known through the following interview transcripts.

(044)P : Before you solve the problem, what would you do?
(044)S₂ : Arrange a settlement strategy, Sir
(046)P : Can you?
(046)S₂ : (S₂ see the problem)
I'm sure I can, sir
(050)P : So what are your plans like?
(050)S₂ : Using unilateral limit definitions and limit theorems
(051)P : Why are you using that method?
(051)S₂ : To make it easier to find out whether the limit value of a function exists or not, sir and the usual questions like that use the limit theorem
(052)P : Can you write?
(052)S₂ : Yes, can sir
3.2.3. Phase of carrying out the plan

At the stage of implementing a male student plan with a field dependent cognitive style ($S_2$) cannot estimate the time to carry out the plan and can review the plans that have been prepared before implementing the limit problem solving, but are less complete, thus affecting the results obtained. After completing the implementation and stating that there are other ways to solve the problem, but have not thought about this method. The explanation given by $S_2$ can be known through the following interview transcripts.

(072)$P$: How long does it take for you to carry out the plan?
(072)$S_2$: I can't estimate Sir
(073)$P$: Then you can start working
(073)$S_2$: Directly done sir?
(074)$P$: Yes, please
(074)$S_2$: Yes, Sir

3.2.4. Phase of looking back

At the stage of looking back at the results of the implementation of problem solving male students with field dependent cognitive style ($S_2$) can also re-examine the suitability of the plan with the results of the implementation of the plan, but less complete and try to match the value of the left limit and right limit obtained by other means, but cannot explain in full. The explanation given by $S_2$ can be known through the following interview transcripts.
(105)P : Do you think that you are working on the problem using the right method?
(105)S2 : Yes Sir
(110)P : Why?
(110)S2 : Because only checking the results, sir, is it as expected or not
(123)P : Are you sure that your work is correct?
(123)S2 : (S2 look back at the results of his work)
    Yes Sir
(124)P : Why?
(124)S2 : Because I have done it the right way Sir, I have checked the results and the results are appropriate Sir

4. Discussion
Further elaborated on the differences in the metacognitive activity of male students based on differences in cognitive styles in solving problems at each Polya stage, which are presented in Table 1, as follows:

Table 1. Metacognitive activity of male student based on differences in cognitive style in solving Problems

| Stages of Polya | Cognitive Style | Male |
|-----------------|-----------------|------|
| Understanding problems |
| Field independent | 1. In an effort to understand the problem of raging information in a complete and ordered manner |
| 2. Planning to read questions without sound (inwardly) repeatedly |
| 3. After monitoring, state the problem in another form completely |
| 4. After re-checking the graphic sketch, checking the correctness of the results, and sure that the evaluation is correct. |
| Field dependent | 1. In an effort to understand the problem of raging information is incomplete and not ordered |
| 2. Planning to read the problem with a voice |
| 3. After monitoring, stating that the problem in other forms is incomplete |
| 4. After reviewing the graphic sketch, checking the correctness of the results, and confident that the evaluation is correct even though there is a mistake. Does not recognize errors and does not make corrections to errors |
| Field independent | 1. Cannot estimate the time to plan on the grounds of difficult limit material |
| 2. Expressing factual knowledge as detailed declarative knowledge |
| 3. Utilize complete declarative, procedural, and conditional knowledge |
| 4. After checking again, do not think about other ways to plan and give the right reasons |
| Devising a plan |
| Field dependent | 1. Can estimate the time to plan, but cannot provide the right reasons |
| 2. Can express factual knowledge as declarative knowledge, but not complete |
| 3. Can utilize declarative, procedural, and conditional knowledge, but lack complete |
| 4. After checking again, do not think about other ways to plan, without the right reasons |
| Stages of Polya | Cognitive Style | Male |
|----------------|-----------------|------|
| Carrying out the plan | Field independent | 1. At this stage, cannot estimate the time to carry out the plan  
2. Can review the plans that have been prepared in advance in full  
3. After checking, sure the work is correct and does not think of other ways to solve the problem |
| Field dependent | 1. At this stage, you can estimate the time to carry out the plan, with the right reasons  
2. Can review the plans that have been prepared in advance, but not complete  
3. After checking again, state that there are other ways to solve the problem, but have not thought about this method. |
| Field independent | 1. Re-examine the suitability of the plan with the results of implementing the plan completely  
2. Match the left limit value and the right limit obtained by other means and explain it in full |
| Field dependent | 1. Re-examine the suitability of the plan with the results of the implementation of the plan, but it is not complete  
2. Matching left limit and right limit values obtained in other ways, but the explanation is incomplete |

In an effort to understand the limit problem of male teacher candidates with independent field cognitive style (S₁) reading the limit problem silently repeatedly, raging information completely, stating the problem in another form completely, re-evaluating the sketch graphs that have been made and sure the results of the evaluation are correct, while male teacher candidates with field dependent cognitive style (S₂) read the limit problem with a voice, shout out information incompletely and not in order, stating the problem in another form with incomplete complete, re-evaluate the graphic sketches that have been made and believe that the results of the evaluation are correct in case there are still errors and do not make improvements. This indicates that male teacher candidates who are field dependent cognitive styles have a tendency to be structured and well organized when doing something or solving problems. The statement is consistent with the opinion that one character of an individual who has an independent field cognitive style is structured and well organized in learning, while an individual who has a field dependent cognitive style is unstructured and not well organized in learning, in this case including when solving problem [25].

Furthermore, when preparing a limit problem solving plan male prospective students with independent field cognitive style can express factual knowledge as detailed declarative knowledge, utilizing the declarative, procedural, and conditional knowledge completely, can explain the limit theorem that is used in detail so as not to think of other ways in making plans and giving the right reasons, while male teacher candidates with field dependent cognitive style express factual knowledge as declarative knowledge, but incomplete, utilizing declarative, procedural, and conditional knowledge with but not complete, can explain the limit theorem used, but it is less detailed and no longer thinks of other ways of making plans without proper reasons [28]. This indicates that male prospective teacher students with independent field cognitive styles are able and confident to be able to connect new information with the knowledge they already have and stored in their long-term memory and can recall when needed. This is consistent with the opinion that someone with an independent field cognitive style can restructure new information and relate it to the knowledge they already have, whereas someone with a dependent field cognitive style is difficult to restructure new information and relate it to the knowledge they have [26].

When implementing the limit problem solving plan that has been prepared, male prospective teacher students with independent field cognitive style cannot estimate the time to carry out the plan, but can review the plans that have been prepared before carrying out the complete problem solving, after completing and stated that sure his work was right and did not think of other ways to solve the problem,
while male teacher candidates with field dependent cognitive style could not estimate the time to implement the plan and could review plans that had been prepared before implementing limit problem solving, but less complete, thus affecting the results obtained. After completing the implementation and stating that there are other ways to solve the problem, but have not thought about this method [26].

At the stage of checking the results of the limit problem solving that has been carried out, male teacher candidates with independent field cognitive style can re-examine the suitability of the plan with the results of the implementation of the plan completely and try to match the value of the left limit and right limit obtained in other ways and explain it completely, while male teacher candidates with field dependent cognitive style can also re-check the suitability of the plan with the results of the implementation of the plan, but are incomplete and try to match the value of the left limit and right limit obtained in other ways, but cannot explain in full [27, 28, 29].

5. Conclusion

Based on the description of metacognitive activities, it shows that male students with filed independent cognitive style, have a tendency to be structured and well organized in solving problems and can restructure new information and connect it with the knowledge they already have, while male students with field dependent cognitive style has characteristics in solving problems tend to be unstructured and not well organized and it is difficult to restructure new information and relate it to the knowledge it has.

Involving metacognitive skills very useful in building the subject's awareness of existing knowledge when solving problems, in the proper context. Therefore, it is suggested to the researcher having a relevant problem to examine more deeply the involvement of metacognitive knowledge in solving the function limit problems in particular and for other problems in everyday life.

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