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Exploring Students' Metacognition in Numeracy Problem Solving: The Role of Reflective and Impulsive Cognitive Styles

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Abstract: The purpose of this study was to describe the metacognition of grade IX students of SMP Negeri 19 Palu in solving numeracy problems based on reflective and impulsive cognitive styles. Metacognition in this study includes three aspects namely awareness, regulation, and evaluation observed at each stage of problem solving according to Polya's model. This descriptive qualitative research used Matching Familiar Figures Test (MFFT-2021), numeracy written test, think-aloud protocol, and in-depth interviews for data collection. In-depth study subjects consisted of two students, one each with reflective cognitive style and one with impulsive cognitive style. The results showed that at the stage of understanding the problem, reflective students showed high awareness and were able to organize their thoughts to understand the context of the problem in depth, while impulsive students tended to be faster in understanding the problem without in-depth analysis. At the stage of developing a plan, reflective students perform good regulation and evaluate the plan made, while impulsive students show awareness and regulation, but the evaluation of the plan is not always consistent. At the stage of implementing the plan, reflective students are able to evaluate the ongoing process, although this evaluation is more visible at the final stage, while impulsive students are less consistent in evaluation during the implementation of the plan, with evaluation only appearing at the final stage. Finally, at the looking back stage, reflective students showed a clear evaluation, although awareness and regulation were not significantly visible, while impulsive students only showed evaluation at the final stage without any deep reflection on the process that had been passed. Overall, reflective cognitive style tends to produce a more complete and in-depth metacognitive involvement in each stage of problem solving, while impulsive style shows a more limited and less consistent involvement in the evaluation aspect.

Keywords: metacognition, numeracy, cognitive style, reflective, impulsive.

▪ INTRODUCTION

Problem solving is one of the abilities that students need to have in learning mathematics. This is in line with (NCTM, 2000) which states that there are five process standards that students need to have through learning mathematics, one of which is problem solving. Problem solving is a complex cognitive process that involves interpreting linguistic information, identifying missing variables, and applying appropriate models to generate effective solutions (Vula et al., 2017; Nguyen et al., 2023). In solving math problems, teachers need to understand how students' thinking process to obtain answers, especially the metacognition process (Purnomo et al., 2017).

The term metacognition was first introduced by Flavell in 1976. Flavell (1976) in (Fathima & Vimala, 2020) argued that metacognition is knowledge and awareness of one's cognitive processes. Students' metacognition process is very important in solving math problems (Braithwaite & Sprague, 2021). Various studies highlight its role in improving students' cognitive processes, enabling them to effectively monitor and adjust their strategies during problem-solving tasks. Metacognition is necessary for success in math problem solving (Izzati & Mahmudi, 2018). Students who have good metacognition

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skills tend to provide correct answers to problems, and can identify the conditions and objectives of the problem, apply various solution strategies, and evaluate the correctness of the solutions found (Güner & Erbay, 2021). Research by Utami, et al. (2023) also shows that students with higher metacognition skills are likely to possess better problem solving skills.

In problem solving, a person's metacognition process can be observed and studied from three aspects. The three aspects are awareness, regulation, and evaluation (Wilson & Clarke, 2004). As the findings of (Adinda et al., 2023) which found that metacognition consists of three aspects, namely awareness, regulation, and evaluation which are related to students' activities in solving mathematical problems. One approach that is often referred to in problem solving is the steps developed by (Polya, 1973), which include; (1) understanding the problem, (2) developing a plan, (3) carrying out the plan, and (4) looking back. Each stage encompasses metacognitive components, requiring students to be aware of the strategies employed, regulate the problem-solving process and evaluate the answers obtained. Therefore, understanding how students apply metacognition in following the stages of problem solving is important to be able to help educators in designing more effective interventions to improve students' thinking skills.

Every student has different problem solving skills. The ability to solve math problems may be affected by cognitive style (Susandi et al., 2019; Son et al., 2020). Cognitive style is a individual's tendency to process information, which includes how to reflect and process information, attitudes towards information, and habits related to the learning environment (Zakiah, 2020). Cognitive style is a characteristic of an individual that is consistent that can become a habit (Zulfa et al., 2024). Experts have classified individual cognitive styles. Kagan (2016) in (Demitra et al., 2023) classifies two types of cognitive styles, namely reflective and impulsive. Individuals with reflective cognitive styles tend to take longer to solve problems, but are more thorough and accurate, so the answers given are usually correct. Conversely, individuals with impulsive cognitive style solve problems quickly but less thoroughly, so the answers given are often wrong.

Minimum Competency Assessment (MCA) is an assessment of the basic competencies required by all learners to be able to develop their capacities and contribute positively in society (Kemendikbud, 2020). The competencies tested in the MCA are reading literacy and numeracy. In this study, the focus is on numeracy problems. Numeracy problems not only test basic arithmetic skills, but also require students to think critically and analytically in solving more complex problems. Research in the context of numeracy problems is important because numeracy problems are designed with different characteristics than conventional math problems in schools. Numeracy problems are more oriented to real-life contexts, are open-ended, and often do not have one definite answer, thus demanding a deep understanding of concepts, selection of appropriate strategies, and active monitoring of the thinking process. Therefore, the use of metacognition - awareness, regulation and evaluation of thinking processes - has the potential to emerge in unique ways in solving numeracy problems. Understanding how students activate their metacognition in solving numeracy problems can provide important insights for the development of learning strategies that are more effective and relevant to the current demands of national assessment.

Research on metacognition and cognitive style has been widely done, especially in the context of mathematical problem solving. Study conducted by Kartika & Muhassanah

(2023) in the context of linear algebra problems demonstrate that subjects with both reflective and impulsive cognitive styles engaged in all activities related to metacognitive awareness and regulation, as well as several aspects of metacognitive evaluation. Then the findings of Ikhwani, et al. (2023)'s study found that students with reflective cognitive styles experienced all metacognitive activities in solving the problems given, namely, experiencing metacognitive awareness activities at the stage of understanding the problem, experiencing metacognitive evaluation activities at the stage of devising a plan, experiencing metacognitive regulation activities at the stage of carrying out the plan, and experiencing metacognitive evaluation activities at the stage of looking back. Therefore, this study will further examine how the metacognition of students with reflective and impulsive cognitive styles in solving numeracy problem.

▪ METHOD

Participants

The subjects of this study were two ninth-grade students at SMP Negeri 19 Palu, consisting of one student with a reflective cognitive style and one student with an impulsive cognitive style. The subjects in this study were selected from 19 ninth-grade students at SMP Negeri 19 Palu who took the Computer-Based National Examination in 2023 when they were still in eighth grade.

The subjects were selected based on their ability to communicate well when expressing their opinions both orally and in writing, as assessed by their mathematics teacher. The subjects were selected based on reflective and impulsive cognitive style categories. To classify cognitive styles in this study, students were given the MFFT-2021 (Matching Familiar Figures Test-2021) test, which had been tested for validity and reliability by Viator and colleagues in 2022. This test aims to determine whether students belong to the reflective or impulsive category. Students must select images that match the standard images. The results of the MFFT test were abstracted and interpreted using cognitive style classification criteria according to quadrants with a median time axis (t) and accuracy score (a). The criteria for grouping cognitive styles can be seen in the graph and table below:

The criteria used to categorize students' cognitive styles can be seen in the following table:

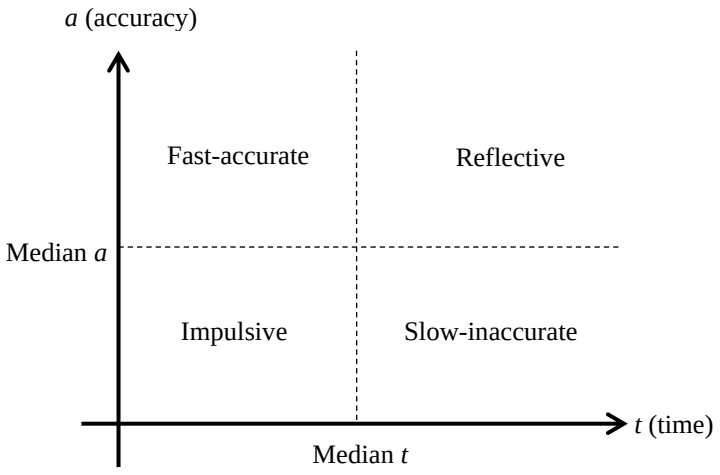


Figure 1. Reference chart for detecting cognitive style

Table 1. Reference for determining students' cognitive styles

Cognitive Style	Time (second)	Accuracy
Fast-accurate	$t \leq$ median time	$a \geq$ median accuracy
Reflective	$t \geq$ median time	$a \geq$ median accuracy
Impulsive	$t <$ median time	$a <$ median accuracy
Slow-Inaccurate	$t >$ median time	$a <$ median accuracy

Research Design and Procedures

This study is an exploratory study with a qualitative approach. A qualitative approach was used because it allows for in-depth data collection through interviews, observations, and analysis of tasks or problem-solving processes. This study was conducted to obtain descriptive data obtained from the subjects' worksheets, think-aloud transcripts, and interview transcripts. The purpose of this study is to describe the metacognition of ninth-grade students at SMP Negeri 19 Palu in solving AKM numeracy problems, viewed from reflective cognitive style and impulsive cognitive style. This study was conducted over a period of approximately two months, beginning with the observation stage, which involved selecting research subjects based on their cognitive styles obtained from the results of the Matching Familiar Figure Test-2021. After obtaining two research subjects, the subjects were given a numeracy test to be completed using the think-aloud protocol method. After completing the test, the subjects were interviewed to determine their metacognitive processes.

Instrument

The research instruments used in this study consisted of primary and supporting instruments. The primary instrument in this study was the researcher himself. The supporting instruments included the Matching Familiar Figure Test-2021 (MFFT-2021), a written test in the form of numeracy questions, and interview guidelines. The MFFT-2021 instrument consists of 20 questions. The MFFT-2021 instrument is used to measure reflective and impulsive cognitive styles based on two main aspects, namely accuracy scores and first response time. High accuracy scores and slower response times indicate a reflective tendency, while low accuracy scores with fast response times indicate an impulsive tendency. In this study, the MFFT-2021 instrument was adapted from the original version by translating the instructions into Indonesian and adjusting the images to better suit the context of the research participants. This adaptation was carried out without changing the structure, content, or number of questions in the test. The test instrument has been validated and reliability tested by Viator, et al. (2022). Additionally, the researcher consulted the instrument with a research instrument validator, who is a lecturer in the Mathematics Education Program at the Faculty of Education and Teacher Training, Tadulako University.

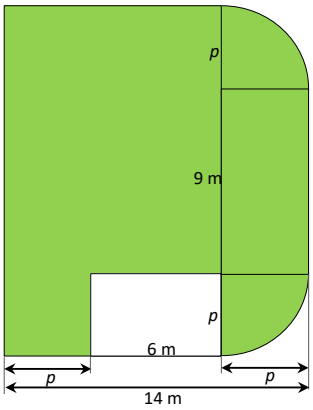
The written test instrument used in this study consists of one numeracy question in the geometry and measurement domain with an application cognitive level, taken from the book by Erlangga (2020). Cognitive level of the questions The test instruments were designed by the researcher and then validated by a lecturer from the Mathematics Education Program at the Faculty of Education and Teacher Training, Tadulako University. The validation of the written test instruments was assessed based on several aspects, namely construction, content, and language. The construction aspect was assessed based on the instructions/questions that required detailed answers, as well as

ensuring the alignment of the questions with the research objectives and focus, particularly in measuring the metacognitive process. The content aspect includes the alignment of question formulations with the educational level, the clarity of question formats, and the relevance of questions to the Minimum Competency Assessment (MCA). The language aspect was evaluated based on the proper use of Indonesian language rules and the simplicity of sentences to avoid misunderstandings in question comprehension. Based on the evaluator's assessment, the developed instrument is suitable for use as a research instrument without revisions.

The interview guidelines in this study are semi-structured, allowing flexibility in exploring in-depth information while still referring to a framework of questions prepared in advance. The questions are structured based on three main aspects of metacognition—awareness, regulation, and evaluation which are systematically linked to each stage of problem solving according to Polya. The following is the metacognition test (MCA numeracy question) in Figure 1 used in this study.

MCA Numeracy Question

Stimulus 1



Home Page

There is a saying that my home is my heaven, which means that a house can make its inhabitants feel comfortable at home. To create a paradise at home, the inside and outside of the house can be arranged as beautifully as possible. One of the arrangements outside the house is also done in the yard. The yard can be arranged by providing plants (grasses) and other ornaments.

The picture on the side illustrates a part of the yard that is planted with grass. On one side of the lawn that is not planted with grass, gravel is given to beautify the decoration of the yard.

Question

Look at stimulus 1. The garden grass that adorns the lawn was purchased from a flower shop.

a. If the unit size of garden grass is 20 cm × 30 cm, how much garden grass should be purchased?
b. If the unit size of garden grass is 25 cm × 25 cm, how much garden grass should be purchased?

(Adapted from Erlangga Book: Fokus AKM SMP/MTs, 2020)

Figure 2. Numeracy question

Data Analysis

The model of Miles, et al. (2014) is applied in this study to analyze the data with three stages, namely data condensation, data display, and conclusion drawing. Data from think-aloud transcripts, in-depth interviews, and students' written responses were condensed through a process of selecting and simplifying data relevant to the research focus, namely metacognitive activities at each stage of Polya. The unit of analysis was determined based on a single utterance or piece of writing that represented a complete metacognitive activity, whether in the form of awareness, regulation, or evaluation. The

coding process was conducted manually using the indicators in Table 1 as a reference, starting with identifying relevant segments, followed by grouping the data into three aspects of metacognition according to Polya's stages, and ending with compiling the emerging patterns. The data are presented qualitatively in the form of narrative descriptions that describe the metacognitive activities of each subject (reflective and impulsive) at each stage of problem solving, accompanied by direct quotations from the transcripts as evidence. Conclusions are drawn through inductive interpretation of findings, taking into account consistency across data, and the verification process is conducted through member check, which involves requesting confirmation from research subjects regarding the researcher's interpretation results to ensure that the interpretation aligns with their experiences and intentions. The indicators employed in this study were derived from the study of Trisna, et al. (2018) and (Kartika & Muhassanah, 2023) and further adjusted to the stages of problem solving according to Polya, can be seen in Table 2. This adjustment is based on the findings of several previous studies which show that metacognition can be studied in each stage of problem solving according to Polya.

Table 2. Metacognition indicators based on polya's problem solving stages

Problem Solving Stages	Aspect of Metacognition	Indicator
Understanding the Problem	Awareness	Students realize what is known and what is asked in the problem (A1)
	Regulation	Students determine the strategy that will be used to understand the problem ((R1)
	Evaluation	Students assess the adequacy of information to solve the problem (E1)
Devising a Plan	Awareness	Students realize the steps that need to be done to solve the problem (A2)
	Regulation	Students determine the solution steps that will be used to solve the problem (R2)
	Evaluation	Students assess the effectiveness of the steps that will be used to solve the problem (E2)
Carrying Out the Plan	Awareness	Students realize what to do (A3)
	Regulation	Students think about what to do next (R3)
	Evaluation	Students check the answer and the appropriateness of the solution steps (E3)
Looking Back	Awareness	Students realize the importance of rechecking the results and process of solving problems (A4)
	Regulation	Students think of another way to solve the problem (R4)
	Evaluation	Students assess the correctness of answers obtained (E4)

▪ RESULT AND DISSCUSSION

Result

Subjects in this study were determined by a cognitive style test, namely the Matching Familiar Figures Test-2021 (MFFT-2021) to 19 grade IX students who participated in the Computer-Based National Assessment (ANBK) in 2023 when they were in grade VIII. Analysis of the Matching Familiar Figures Test (MFFT) results

showed that the median average response time of participants was 14.58 seconds, while the median accuracy score was 80. The data distribution of the MFFT test results is visualized using the scatter plot presented in Figure 2, where the median average response time line is displayed on the X axis (abscissa) and the median accuracy score line is displayed on the Y axis (ordinate).

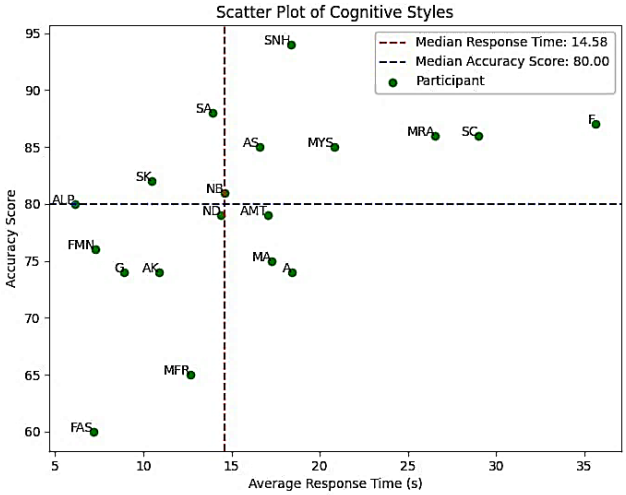


Figure 3. Scatter plot of cognitive style

The results of the scatter plot in Figure 2, identified the tendency of students'cognitive style into four different groups. Researchers summarized the results of cognitive style measurements presented in Table 2, as follows.

Table 3. Cognitive style measurement results

Group	Cognitive Styles	Number of Students
I	Fast-accurate	4
II	Slow-accurate (reflective)	6
III	Fast-inaccurate (impulsive)	6
IV	Slow-innaccurate	3
	Total	19

According to the data in Table 2, among the 19 students, there are 4 fast accurate students, 6 reflective students, 6 impulsive students, and 3 slow accurate students. Furthermore, based on the recommendation of the teacher, the researcher chose one student with reflective cognitive style and one student with impulsive cognitive style with the following considerations: (1) Student willingness, (2) Able to communicate well. Students who were selected as research subjects can be seen in Table 3 below.

Table 4. Subject of research

Student Initials	Cognitive Style	Subject Code
MRA	Reflective	RE

G	Impulsive	IM

Results of Data Analysis of Subjects with Reflective Cognitive Style (RE)

The following Figure 3 below are the results of the reflective subject's written answers.

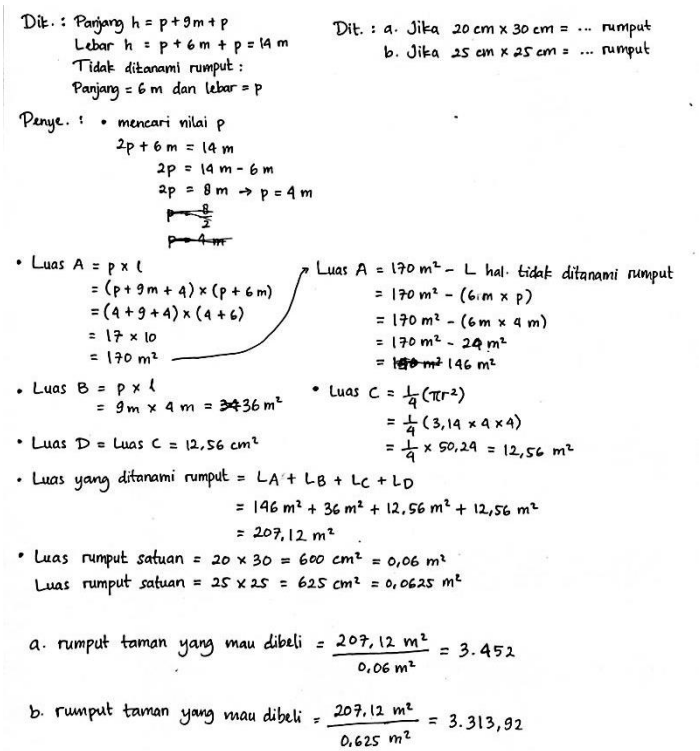


Figure 4. Reflective subject written answers

Stage of Understanding the Problem

The following is the transcript data of RE subject's think-aloud interviews at the stage of understanding the problem:

PN-TA007: What do you understand from the question?
RE-TA008: In this problem, I was told to find how much garden grass to buy.
PN-TA009: Now what are you going to do?
RE-TA010: (The subject seems to start writing the known information).
PN-TA013: What did you do earlier? What did you write?
RE-TA014: I wrote emm... the information in this problem.
PN-TA015: What information do you get from the problem?
RE-TA016: Given the length of the yard= p + 9 m + p and the width of the yard= p + 6 m + p. Then the yard that is not planted with grass, length = 6 m and width = p. Then what is asked, if the unit size of garden grass is 20 cm × 30 cm = ... grass and if the unit size of garden grass is 25 cm × 25 cm = ... grass?

According to the findings of observations on the RE subject's think-aloud interviews process at the stage of understanding the problem, it can be seen that the RE

subject read the problem until it was finished and without rushing. The RE subject then started writing the known information, which showed that the subject attempted to identify the information in the problem to understood. When the researcher asked RE to read out the information obtained from the problem, RE mentioned the known and questioned information. Based on RE's written answer, it can be seen that RE recorded all the important information in the problem. Subject RE realized the known information as well as the problem's requirements. This indicates that the subject has metacognitive awareness in understanding the problem. Next, the in-depth interview transcript data of the RE subject in understanding the problem is presented:

PN-W05: What do you understand this problem?
RE-W06: I read the question until it's finished, and if I still don't understand I reread it again. Then I wrote the known information and the question.
PN-W09: Is the information given enough to solve this problem?
RE-W10: I think the information is enough. We already know the length and width of the yard, and the size of the grass. We just need to do the math.

Based on the results of the interview at the stage of understanding the problem above, to be able to understand the problem, the RE subject apply the strategy of reading the problem until it is finished and reading it repeatedly, then writing the known and asked information. This shows that RE performs metacognitive regulation in understanding the problem. Furthermore, the RE subject assesses that the information provided in the problem is sufficient to solve the problem. This indicates that the RE subject performs metacognitive evaluation in understanding the problem.

Stage of Devising a Plan

The following is the transcript data of RE subject's think-aloud interviews at the stage of devising a plan:

PN-TA035 : Next, how will you start solving the problem? What will you do?
RE-TA036: Okay, what I'm going to do is... find the value of p.
PN-TA037: Why are you looking for the value of p?
RE-TA038: Because... to find the area of this page we have to determine the value of p.
PN-TA039: After finding the value of p what else will you do?
RE-TA040: Calculate the area of the yard.
PN-TA041: Is that your only plan?
RE-TA042: No, sis. I've thought of some steps.
PN-TA043: Can you explain what your plans are?
RE-TA044: First, find the value of p. After that, calculate the area of the lawn planted with grass. Then I also need to calculate the unit grass area. Finally, calculating how much grass to buy. To find out how much grass to buy, I figured out how to divide the area of the lawn planted with grass by the unit grass area.

According to the findings of observations on the process of think-aloud interviews of subject RE at the stage of devising a plan, subject RE stated the steps to be taken, namely finding the value of p. Subject RE realized that the value of p needed to be found

first because it was the key to calculating the area of the yard. Subject RE realized what to do after understanding the problem, namely thinking about the way of problem-solving. This indicates that subject RE has metacognitive awareness in making plans. Subject RE systematically compiled the steps of problem-solving. The preparation of these steps shows that the subject RE performs metacognitive arrangements in preparing the plan. Next, the in-depth interview transcript data of the RE subject in devising a plan is presented:

PN-W23: Before starting the solution, did you have time to think whether your plan was right?
RE-W24: Yes, I think it's right and I also feel quite confident with my plan. I also had time to look for other ways but I couldn't, and finally I used the original plan.

According to the findings of the interview at the stage of devising a plan above, the RE subject assesses the effectiveness of his plan by believing that the plan made is correct. This shows that the RE subject performs metacognitive evaluation in preparing the plan.

Stage of Carrying Out the Plan

The following are the transcripts of RE subject's think-aloud interviews at the stage of carrying out the plan:

RE-TA046: (Started solving by finding the value of p).
PN-TA052: Okay. What else are you going to do?
RE-TA053: Emm, next I will calculate the area of the lawn planted with grass.
PN-TA091: Okay. What else are you going to do?
RE-TA092: next I will calculate the unit area of grass.
PN-TA098: Okay. What else are you going to do?
RE-TA099: Calculating how much garden grass to buy. (The subject realized that the unit area of a lawn planted with grass is different from the unit area of grass).
RE-TA102 : Now I want to change the unit of grass area to meters.
PN-TA103: How do you do that?
RE-TA104: I'll split it by... ten thousand.
RE-TA106: Then, I will divide the area of the yard by the area of the grass unit.

Based on the results of observations on the RE subject's think-aloud interviews process at the stage of carrying out the plan, it can be seen that the RE subject began to solve the problem according to the plan that had been made previously, namely the subject started by finding the value of p. This shows that the RE subject has metacognitive awareness in carrying out the plan. In solving the problem, subject RE worked according to the plan made. Subject RE starts by looking for the value of p. After obtaining the value of p, then subject RE calculates the area of the lawn planted with grass, then calculates the area of the unit grass. Finally, the subject RE divided the area of the lawn planted with grass to determine the amount of grass to buy. This shows that the subject RE makes metacognitive regulation in carrying out the plan. According to the RE subject's written responses during the plan implementation stage, it can be seen that the RE subject often scribbles the answer when the subject realizes an error in the calculation. This shows that

the subject RE evaluates the answers obtained, meaning that the subject performs metacognitive evaluation in carrying out the plan. Next, the in-depth interview transcript data of subject RE in implementing the plan is presented:

PN-W27: Do you think the steps you took were in accordance with the initial plan?
RE-W28: Yes, it's appropriate.
PN-W29: If you find an error in the calculation, what will you do?
RE-W30: I will fix it by recalculating.

According to the results of the interview at the stage of carrying out the plan above, the subject RE stated that the steps taken were in accordance with the initial plan. This shows that the RE subject evaluates the suitability of the solution steps, meaning that the subject performs metacognitive evaluation in carrying out the plan.

Stage of Looking Back

The following are the transcripts of RE subject's think-aloud interviews at the stage of looking back:

PN-TA108: Is it done?
RE-TA109: Already, sis.
PN-TA110: Are you sure about your answer?
RE-TA111: God willing, sure.
PN-TA112: Try to look at your calculation results again. Does the result make sense? For example, is the amount of grass you get too little or too much compared to the size of the yard?
RE-TA113: (Looking back at the calculation results). It seems like the results make sense, sis. You see, the size of the yard is quite large, so it's natural that it needs a lot of grass.
PN-TA114: Okay. Can you summarize your answer?
RE-TA115: Yes. × So, if the unit size of garden grass is 20 cm × 30 cm, the amount of garden grass to buy is 3,452 pieces and if the unit size of garden grass is 25 cm × 25 cm, the amount of garden grass to buy is 3,313.92 pieces.

According to the observation of the RE subject's think-aloud interviews process at the stage of looking back, it can be seen that the RE subject did not independently check the answers obtained. The subject stated that he had finished working on the problem and felt confident in his answer. However, after being given directions by the researcher to recheck the results of his calculations, the subject began to evaluate whether his answer made sense by considering the size of the lawn and the amount of grass needed. The subject finally concluded that the answer was logical because the size of the yard was large enough to require a large amount of grass. This shows that the RE subject performs metacognitive evaluation in checking back, but the metacognitive awareness to check back the answer has not appeared independently, but rather still relies on external encouragement. Next, the in-depth interview transcript data of the RE subject at the stage of looking back is presented:

PN-W31: If there is another way to solve this problem, can you think of it?
RE-W32: No, sis.

As the results of the interview at the stage og looking back above, that the RE subject did not consider other alternatives to solve the problem given. This indicates that the RE subject did not make metacognitive regulation in looking back.

Results of Data Analysis of Subjects with Impulsive Cognitive Style (IM)

The following Figure 3 below are the results of the impulsive subject's written answers.

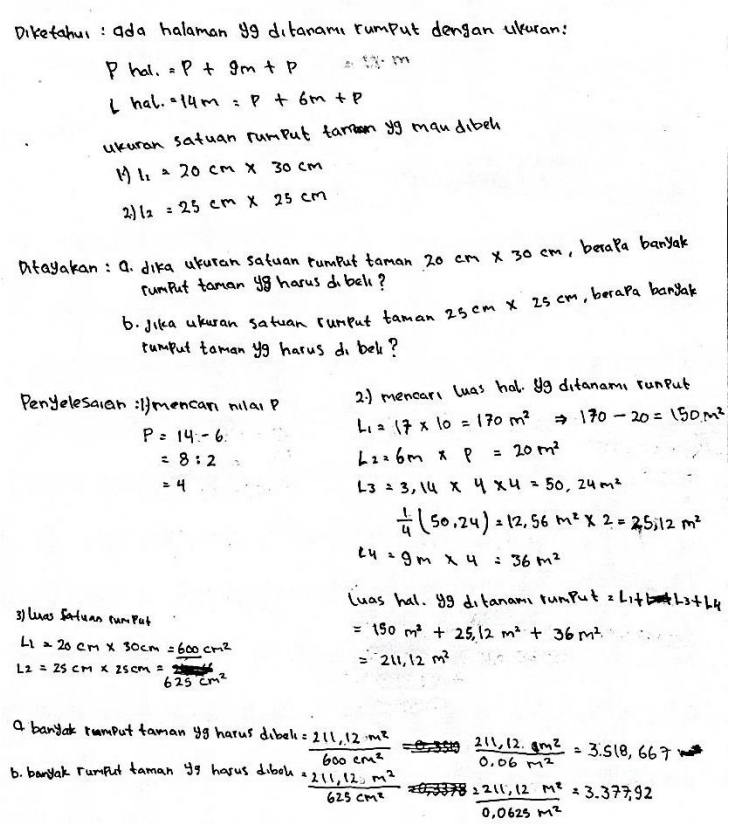


Figure 3. Impulsive subject written answers

Stage of Understanding the Problem

The following are the transcripts of think-aloud interviews of IM subjects at the stage of understanding the problem:

IM-TA002: ... Okay, I'll start working on the question. (The subject reads the problem aloud until it is finished).
PN-TA003: Do you understand the question?
IM-TA004: Emm, just understood a little bit.
PN-TA005: What have you understood from the question?
IM-TA006: So, here is an illustration of a house yard that is planted with grass. Then on one side of the yard there is no grass. Then the shape of the yard is like a combination of a rectangle and a semicircle.
PN-TA007: Okay. Now what are you going to do?
IM-TA008: Now I will write down the known information.

IM-TA010: (After finishing writing, the subject read out the known information). It is known that there is a yard planted with grass with the size of the length of the yard = p + 9 m + p and the width of the yard = 14 m = p + 6 m + p. The size of one unit of grass that you want to buy, namely (1) 20 cm x 30 cm and (2) 25 cm x 25 cm. Next, I want to write down the question.

IM-TA012: (After finishing writing, the subject read out the information asked). So, here what is asked, if the unit size of garden grass is 20 cm x 30 cm, how much garden grass should be purchased and if the unit size of garden grass is 25 cm x 25 cm, how much garden grass should be purchased?

According to the findings of observations on the process of think-aloud interviews of IM subjects at the stage of understanding the problem, it can be seen that IM subjects read the problem until it is finished and without rushing. This shows that the subject tries to understand every detail of the problem given. Although subject IM admitted that he "only understood a little" after reading, subject could identify the important elements of the problem, such as the illustration of a lawn planted with grass and the shape of the lawn which is a combination of a rectangle and a semicircle. IM subject then began to write the known and questionable information from the problem which showed that the subject tried to identify the information in the problem to be understood. Based on IM's written answers at the problem understanding stage, it can be seen that IM recorded all the important information in the problem. This process shows that IM subject has metacognitive awareness in understanding the problem. Next, the in-depth interview transcript data of IM subject at the stage of understanding the problem is presented:

PN-W05: How do you understand this problem?

RE-W06: I read the question as a whole, and find out what is known and asked from the question.

PN-W07: Is the information given enough to solve this problem?

RE-W08: Already.

Based on the results of the interview at the stage of understanding the problem above, to be able to understand the problem, subject IM uses the strategy of reading the problem as a whole to find out the known and questionable information. This shows that IM subjects make metacognitive regulation in understanding the problem. Furthermore, the IM subject assesses that the information provided in the problem is sufficient to be solved. This indicates that the RE subject performs metacognitive evaluation in understanding the problem.

Stage of Devising a Plan

The following are the transcripts of IM subject's think-aloud interviews at the stage of devising a plan:

PN-TA011: You have written the known and questionable information. What will you do next?

IM-TA012: (Pauses, seems to be thinking) I thought about how to figure out how much garden grass to buy.

PN-TA013: Can you think of a way?

IM-TA014: Wait, sis. (Rereading the problem) I think if we want to know how much grass is needed, we must first know the total area of the yard. After that, I divided it by the area of one piece of grass. Is that right, sis?
PN-TA015: Do you think that step is in accordance with what the question asks?
IM-TA016: Emm ... I think it's appropriate, sis.
PN-TA017: Okay. Can you explain in more detail how you will solve this problem?
IM-TA018: (Looking back at the question and answer sheet).
PN-TA019: So, how was it?
IM-TA020: Okay, sis. So, in this picture, the length and width of the page are still unclear. We have to find the p value first.
PN-TA021: Okay, continue?
IM-TA022: After I get the value of p, then I find the area of the yard planted with grass. Then, when I got the area of the yard planted with grass, I looked for the area of one unit of grass. After that... Well, then find how much grass to buy by dividing the area of the yard planted with grass by the area of one unit of grass.

According to the findings of observations on the process of think-aloud interviews of IM subjects at the stage of devising a plan, IM subjects stated that the next thing to do was to think about how to find how much grass to buy. This shows that the subject has metacognitive awareness in making plans. Although initially seemed hesitant, IM subjects can develop a problem-solving strategy. Subject IM determined the first step, which was to find the value of p because the length and width of the yard were still unclear. Furthermore, subject IM planned to calculate the area of the lawn planted with grass, then calculate the area of the unit grass. Finally, subject IM would calculate the amount of grass to be purchased by dividing the area of the lawn planted with grass by the unit grass area. The preparation of these steps shows that subject IM performs metacognitive regulation in devising a plan. Next, the in-depth interview transcript data of IM subject at the stage of devising a plan is presented:

PN-W15: Before starting the solution, did you think about whether your plan was right?
IM-W16: At first I was hesitant, but that's the only way that immediately came to mind, and I think the method is appropriate.

Based on the results of the interview at the stage of devising a plan above, the IM subject assessed the effectiveness of the plan made by saying that the plan made was appropriate. This shows that the subject performs metacognitive evaluation in devising a plan.

Stage of Carrying Out the Plan

The following are the transcripts of think-aloud interviews of IM subjects at the stage of carrying out the plan:

IM-TA028: ... (Starts writing the solution). Okay, first I want to find the value of p first.
PN-TA032: Okay. What else are you going to do?
IM-TA033: Then calculate the area of the lawn planted with grass.

PN-TA036: Okay, which part do you want to calculate the area of first?
IM-TA037: This one and this one (pointing to the picture).
PN-TA041: Which part do you want to calculate next?
IM-TA042: This one (pointing to the picture).
PN-TA050: Okay. So what else are you going to do?
IM-TA051: Next, I will calculate the area of this part using the rectangle area formula.
IM-TA053: Now just add them up.
PN-TA055: You've got the area of the lawn planted with grass. What else are you going to do?
IM-TA056: Next I will calculate the area of the grass. (Continues writing).
PN-TA058: Next, what else are you going to do.
IM-TA059: Now it's just a matter of calculating how much grass to buy. (Continues writing).
IM-TA060: Done. So, if the unit size of garden grass is twenty centimeters by thirty centimeters, the amount of garden grass to buy is 0,3519

The findings of observations on the process of think-aloud interviews of subject IM at the stage of carrying out the plan, shows that subject IM began to solve the problem in accordance with the plan that had been made previously, namely the subject started by finding the value of p. In solving the problem, subject IM worked according to the plan that had been made. The IM subject starts by looking for the value of p. After obtaining the value of p, then the IM subject calculates the area of the lawn planted with grass, then calculates the area of the unit grass. Finally, the IM subject divided the area of the lawn planted with grass to determine the amount of grass to buy. This shows that the subject has metacognitive awareness in carrying out the plan. In that stage, subject IM can think of the next steps that need to be taken. This shows that the IM subject performs metacognitive arrangements in carrying out the plan. As the IM subject's written respons at the stage of implementing the plan, it appears that there are incorrect calculation results. This shows that the subject lacks evaluation of the answers obtained, meaning that the subject lacks metacognitive evaluation in carrying out the plan. Next, the in-depth interview transcript data of IM subject in implementing the plan is presented:

PN-W21: Do you think the steps you took were in accordance with the initial plan?
IM-W22: Yes, I think it's appropriate.

According to the results of the interview at the stage of carrying out the plan above, the IM subject stated that the steps taken were in accordance with the initial plan. This shows that subject IM performs metacognitive evaluation at the stage of carrying out the plan.

Stage of Looking Back

The following are the results of the transcript of IM subject's think-aloud interviews at the stage of looking back:

PN-TA061: Are you sure about your answer? Doesn't it make sense that zero grass was bought?
IM-TA062: No way.
PN-TA063: That means there is something wrong with your steps. Try to check again.

IM-TA064: (Rechecked his answer, but could not find the error).
PN-TA065: ... (pointing out the subject's mistake).
PN-TA074: Now, look again, does it make sense?
IM-TA075: Yes, it makes sense, sis.
PN-TA076: Okay, now can you summarize your answer?
IM-TA077: Yes. So, if the unit size of garden grass is 20 cm × 30 cm, the amount of garden grass to buy is 3,518.667 pieces, and if the unit size of garden grass is 25 cm × 25 cm, the amount of garden grass to buy is 3.377,92 pieces.

Based on the results of observations on the process of think-aloud interviews of IM subjects at the stage of looking back, IM subjects began to check their answers when given feedback by the researcher that the answers obtained did not make sense. When reexamining the steps, subject IM had difficulty finding the location of his mistake. The subject only realized the location of his mistake after being directed by the researcher. In addition, the subject also considered whether the final result was logical or not. This shows that subject IM performs metacognitive evaluation at the recheck stage, but metacognitive awareness to recheck the answer has not yet emerged independently, but rather still relies on external encouragement. Next, the in-depth interview transcript data of IM subject at the stage of looking back is presented:

PN-W31: If there is another way to solve this problem, can you think of it?
IM-W32: No, sis.

Based on the results of the interview at the stage of looking back above, the IM subject did not consider other alternatives to solve the problem given. This shows that IM subjects do not make metacognitive arrangements in checking back.

Discussion

Based on the results of data analysis, the following is a description of the students' metacognition.

Students' Metacognition with Reflective Cognitive Style in Solving Minimum Competency Assesment Type Numeracy

At the stage of understanding the problem, reflective students show metacognitive awareness by realizing the information known and asked in the problem. As the study conducted by Ikhwani, et al. (2023) which founds that students with reflective cognitive style have metacognitive awareness at the stage of understanding the problem, where students rethink the information asked known and asked in the problem. In addition, students also perform metacognitive arrangements by reading the problem repeatedly and writing down important information to aid understanding. The study by Trisna, et al. (2018) also found that students with certain cognitive styles perform metacognitive regulation by setting reading strategies to understand the problem. Metacognitive evaluation is also seen when reflective students ensure that the information in the problem is sufficient to solve.

At the stage of devising a plan, reflective students have metacognitive awareness indicated by students realizing the steps that will be used to problem-solving. Reflective students carry out metacognitive regulation by systematically compiling a solution strategy, including determining the steps that must be taken. As the study conducted by

Kartika & Muhassanah (2023) which founds that students with reflective cognitive style can perform metacognitive regulation, namely planning problem solving strategies to be used. Reflective students also perform metacognitive evaluation by considering the effectiveness of strategies that have been made and ensuring that there are no other alternatives that are more efficient. This is in line with the research Ikhwani, et al. (2023) which also found that students with reflective cognitive style perform metacognitive evaluation at the stage of devising a plan, where students rethink the plan to be used in solving the problem.

At the stage of carrying out the plan, reflective students have metacognitive awareness what to do next after making a plan, namely solving the problem according to the plan made. Reflective students perform metacognitive regulation by solving according to the steps that have been planned, and consciously organize what steps to do next. As the study conducted by Ikhwani, et al. (2023) which also found that students with reflective cognitive style perform metacognitive regulation at the stage of carrying out the plan, where students think about the steps in solving the problem. Reflective students also perform metacognitive evaluation by crossing out and correcting the answer when they realize an error in the calculation. In addition, reflective students evaluate the suitability of the steps taken with the initial plan that has been prepared.

At the stage of looking back, reflective students have not fully demonstrated metacognitive awareness independently. Reflective students only checked after getting encouragement from the researcher. Nevertheless, after being directed, students are able to conduct metacognitive evaluation by assessing whether the results obtained make sense based on the size of the lawn and the amount of grass needed. As the study conducted by Kartika & Muhassanah (2023) which founds that students with reflective cognitive style perform metacognitive evaluation by assessing the results obtained. The study by Ikhwani, et al. (2023) also found that students with reflective cognitive style perform metacognitive evaluation at the stage of checking back, where students rethink the results of the answers obtained by checking back. Another shortcoming is that reflective students do not show exploration of other alternative solutions, which indicates a lack of metacognitive regulation in considering alternative strategies.

Students' Metacognition with Impulsive Cognitive Style in Solving Minimum Competency Assesment Type Numeracy

At the stage of understanding the problem, impulsive students have metacognitive awareness indicated by thinking about the information known and asked in the problem. As the study conducted by Kartika & Muhassanah (2023) which founds that students with impulsive cognitive styles perform metacognitive awareness activities, namely students are able to think about what they known from the problem. Students also perform metacognitive arrangements by reading questions to find important information. Metacognitive evaluation is also done by ensuring that the information in the problem is sufficient to solve it. The study by Trisna, et al. (2018) which also found that students with certain cognitive styles perform metacognitive regulation by determining reading strategies to understand the problem and perform metacognitive evaluation by assessing the correctness of their understanding.

At the stage of devising a plan, impulsive students show metacognitive awareness by thinking about the method that will be used to solve the problem. Impulsive students

perform metacognitive arrangements, indicated by students' ability to determine the strategies or steps that will be used to solve the problem. These findings are in line with research conducted by Kartika & Muhassanah (2023) which states that students with impulsive cognitive style can perform metacognitive regulation activities, namely mentioning and explaining the solution steps used. Students with impulsive cognitive style also perform metacognitive evaluation, where students are able to assess the effectiveness of the strategy to be used by stating their belief that the solution strategy to be used is appropriate. The study by Trisna, et al. (2018) which also found that students with certain cognitive styles perform metacognitive evaluation of the effectiveness of the method to be used by expressing confidence in the method.

At the stage of carrying out the plan, impulsive students have metacognitive awareness of what to do next after making a plan, namely solving the problem in accordance with the plan made. Other findings in this study also showed that students with impulsive cognitive style perform metacognitive regulation by solving in accordance with the steps that have been planned, and consciously organize what steps should be done next. As the study by Trisna, et al. (2018) which also found that students with certain cognitive styles perform metacognitive arrangements by working according to the plan they made. Students with impulsive cognitive style still lack of metacognitive evaluation of the answers obtained. Students with impulsive cognitive style only evaluate the suitability of the solution steps taken with the initial plan.

At the stage of looking back, impulsive students have not shown metacognitive awareness independently in evaluating their answers. Students only checked after getting feedback from the researcher. In addition, students had difficulty in finding the location of the error independently and only realized the error after being directed. Metacognitive evaluation is done by considering whether the answer makes sense or not. This finding is in line with research conducted by Kartika & Muhassanah (2023) which states that students with impulsive cognitive style perform metacognitive evaluation by assessing the results obtained. Impulsive students do not show exploration of other alternative solution strategies, which indicates a lack of metacognitive regulation in considering other ways to solve the problem.

▪ CONCLUSION

According to the study findings and discussion, it can be concluded that students with reflective cognitive styles engage all metacognitive activities – representing the aspects of awareness, regulation, and evaluation- throughout nearly every stage of Polya's problem-solving process, except in the "looking back" stage, where only the evaluation aspect is evident. In contrast, students with impulsive cognitive styles demonstrate all metacognitive activities related to awareness, regulation, and evaluation primarily during the stage of understanding the problem and devising a plan. During the carrying out the plan, they do not consistently exhibit the evaluation aspect, and the "looking back" stage, only the evaluation aspect is present.

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