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STUDENTS' METACOGNITIVE SKILLS IN SOLVING PROBABILITY INVESTIGATION-BASED PROBLEM

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ABSTRAK

Penelitian ini bertujuan untuk untuk mendeskripsikan kemampuan metakognitif siswa dalam pemecahan masalah peluang bernuansa penyelidikan berdasarkan kemampuan matematika siswa kelas 12 di salah satu SMA di Kabupaten Kediri, Jawa Timur, Indonesia. Penelitian ini menggunakan jenis deskriptif, dengan dengan pendekatan kualitatif. Teknik pengumpulan data berupa pemberian tes dengan metode *think-aloud* dan wawancara semi terstruktur. Instrumen penelitian terdiri dari tes masalah bernuansa investigasi dan pedoman wawancara. Subjek penelitian terdiri dari tiga siswa kelas 12 masing-masing dengan kemampuan matematika tinggi, sedang, dan rendah. Hasil penelitian ini menunjukkan bahwa pada tahap memahami masalah aktivitas metakognitif muncul berupa *awareness* dan *evaluation*. Namun, subjek rendah tidak melakukan *awareness* dengan baik dan subjek sedang tidak melakukan evaluasi dengan cermat terkait hasilnya. Tahap menyusun rencana, subjek tinggi dan sedang menggunakan aktivitas *regulation* dengan memikirkan strategi yang tepat. Aktivitas *evaluation* seperti keyakinan efektivitas strategi serta menilai tepat hasilnya. Tahap mengimplementasi rencana, subjek tinggi dan sedang menggunakan aktivitas *regulation* dengan memonitor solusi yang direncanakan dengan tepat. Aktivitas *evaluation* dilakukan dengan penilaian yang tepat pada tiap hasilnya. Namun, muncul sebaliknya pada subjek rendah di kedua tahap tersebut. Pada tahap melihat kembali, aktivitas *evaluation* muncul berupa menilai kesesuaian jawaban dengan konteks masalah bernuansa investigasi, namun tidak ditemukan aktivitas metakognitif pada subjek rendah.

Kata kunci: Aktivitas Kesadaran, Aktivitas Evaluasi, Aktivitas Regulasi, HOTS

Abstract

This study aims to describe the metacognitive abilities of students in solving opportunity problems with nuanced investigations based on the mathematical abilities of grade 12 students in one of the high schools in Kediri Regency, East Java, Indonesia. This research uses a descriptive type, with a qualitative approach. Data collection techniques in the form of giving tests with the think-aloud method and semi-structured interviews. The research instrument consisted of a problem test with investigative-based and interview guidelines. The research participants consisted of three grade 12 students each with high, medium, and low mathematical abilities. The results of this study indicate that at the stage of understanding the problem, metacognitive activity appears in the form of awareness and evaluation. However, the low participant was not able awareness in a good way and the medium participant was not doing a careful evaluation of the results. In the planning stage, the high and medium participants currently use regulation activities by thinking about the

right strategy. Evaluation activities, such as believing in the effectiveness of the strategy and assessing the results appropriately. In the stage of implementing the plan, the high and medium participants are using regulation activities by monitoring the planned solutions properly. Evaluation activities are carried out with an appropriate assessment of each result. However, the opposite appeared for low participant in both previous stages. In the stage of looking back, evaluation activity appears in the form of assessing the suitability of answers to the context of the problem with investigative nuances, but no metacognitive activity was found in low participant.

***Keywords**: Awareness Activity, Evaluation Activity, Regulation Activity, HOTS*

INTRODUCTION

Mathematics education plays a central role in the aspect of education, as an effort to improve the quality of education (Pramono, 2017). Mathematics has a positive impact on everyday life, because mathematics can make a complete human being, namely a human who can solve problems (Siagian, 2017). In Permendiknas (Regulation of the Minister of National Education) Number 23 of 2006 states that one of the goals of learning mathematics is that students become good problem-solver (Arum, 2017)

In the process of solving mathematical problems, students certainly understand the problem, plan the strategies that will be used, and interpret the solutions obtained, make decisions (Sumartini, 2016; Wulan & Anggarini, 2019). Problem-solving is not only the goal of learning mathematics but also the basis for achieving the goals of learning mathematics (NCTM, 2000). Problem-solving is a thought that is directed, to find solutions to specific problems and their use in life (Amarel, 2019; Carson, 2007).

The problem presented must be following one's cognitive condition. The opinion above explains that problem-solving can be solved by using cognitive abilities (Saputra & Andriyani, 2018). However, cognitive abilities are not sufficient to solve the problem. Students can regulate their cognitive abilities by using an unusual way, where this method can evaluate every step taken during problem-solving. Managing them all requires a metacognitive skills (Hargrove, 2013; Meijer et al., 2006).

Metacognitive skills are knowledge and control in student learning activities, which plays an important role in obtaining information, reading, understanding problem-solving, and controlling one's self (Wardana et al., 2021; Wulan et al., 2021). Metacognitive skills are the ability to think, be aware of factors that affect intellectual performance, and know when, where, and why certain strategies help students in learning performance (Garofalo &

Lester, 1985; Ku & Ho, 2010; Lai, 2011; Zega, 2021). Some metacognitive activities in the context of solving mathematical problems are metacognitive awareness, metacognitive regulation, and metacognitive evaluation (Magiera & Zawojewski, 2011). Metacognitive skills are related to HOTS (High Order Thinking Skill) questions, because HOTS problems can demand more complex thinking in solving problems (Albab & Indriati, 2020; Ansari & Saleh, 2021; Hamzah et al., 2022).

Based on observations made in one of the high schools in Kediri Regency, it was found that the problem-solving abilities of the students grade 12 were very different. In solving problems there are students who work on problem-solving questions using techniques or ways that are not correct. Students tend to be able to find answers to problem-solving questions with a less coherent process, and students feel confused in finding ways to solve problem-solving that are directly related to everyday life. On the other hand, there are students who are capable of solving problem-solving questions using a coherent process. The teachers are not accustomed to giving problem-solving questions that are nuanced in investigation.. Most mathematics teachers rarely give math problems in non-routine questions (Irawan et al., 2021; Hidayah et al., 2022; Rambe, 2019). After the students were asked to solve the investigation-based problem in probability material, it was found that students' abilities were very different. But, there is no broader description how students' the metacognitive activities in solving the given problem.

Using metacognitive awareness in solving HOTS problems, a person will understand the knowledge he has in solving problems appropriately (Wardana et al., 2021). According to the level of the sequence of thinking about HOTS questions, namely level C4 to level C6, which is more directed to the nuanced question of investigation is the HOTS level C5 (evaluating) question. At this level students are required to think critically and creatively in assessing and deciding actions in dealing with problems (Anderson & Krathwohl, 2001; Fanani & Kusmaharti, 2018). The ability to evaluate the right can support students to follow the progress or development of a problem solving and make decisions about solving problems appropriately (As'ari, 2019). Dealing with the investigation-based problem, students are expected to be able to make assumptions or conjectures, predict, test, and assess. Students' metacognitive skills need to be trained and accustomed to equip students to solve the type of problems in everyday life (Rambe, 2019). Therefore, this study provides an in-depth description of metacognitive abilities when solving investigation-based problem.

Metacognitive skills have been widely studied related to problem-solving abilities, which are influenced by students' ability to solve problems including some research (Adinda et al., 2021; Albab & Indriati, 2020; Arum, 2017; Faizati, 2020; Lusiana et al., 2020; Nurita & Sari, 2021; Pramono, 2017; Rambe, 2019; Safitri et al., 2020; Tachie, 2019). Metacognitive skills in solving investigations-based problem is considered important in developing learning programs and there are still limited studies on this matter. This study considers it necessary to find out about students' metacognitive skills in solving investigations-based problem. The purpose of this study is to describe students' metacognitive skills in solving probability investigations-based problem based on high, medium, and low-level mathematical abilities.

RESEARCH METHOD

This research is to describe students' metacognitive skills in solving probability investigations-based problems based on high, medium, and low-level mathematical abilities. Based on these objectives, this research is classified as exploratory research with a qualitative approach. This research was conducted at a senior high school that is classified as Superior in Kediri Regency. Collecting the data was carried out in the second semester of 2021/2022 academic year.

The research participants in this study were in grade 12 that classified into three levels of mathematics ability based on problem-solving skills. The participant was selected by giving a test problem-solving and categorized into three levels high, medium, and low-level as Table 1 (Maryam, 2016). In determining the participants for the interview, the researcher chose one participant for each category who had good communication and interpersonal skills. The researcher also consulted with several teachers at the school to determine these participants.

Table 1. Mathematics Ability Categorization

No.	Score Interval for x	Category
1.	$80 \leq x \leq 10$	High
2.	$60 \leq x < 80$	Medium
3.	$0 \leq x < 60$	Low

Data were collected by using investigation-based problem-solving tests with think-aloud methods and interviews. The data obtained are the results of problem-solving performance and the results of interview transcripts with students. The instruments in this study

were test and interview guidelines. The instruments have been validated by two experts in mathematics education.

The test instrument was developed in the form of a description of the problem-solving investigation about three problems which were carried out simultaneously with the think-aloud method. Since we want to explore what the participants think while solving the problem, in a think-aloud protocol, a participant is given the problems and asked to talk out loud while they work or read. Think-aloud protocols are frequently used when investigating metacognitive engagement as they allow researchers to gather information about metacognitive engagement while a participant is engaged in an activity of interest, such as solving a problem (McCord & Matusovich, 2019). Responses are coded to determine what metacognitive strategies were used. When this method is applied, participants are asked to spontaneously report everything that goes through their minds while doing a problem-solving task, and they are instructed not to interpret or analyze their thinking (Güss, 2018). Meanwhile, the interview guidelines were used to further explore students' metacognitive abilities and to see the relationship between students' metacognitive abilities in problem-solving. The test instrument can be seen in Figure 1 and the metacognitive activities will be coded using a framework in Table 2 (Magiera & Zawojewski, 2011).

Furthermore, the data analysis technique in this study refers to the data analysis technique of the Miles and Huberman model, which includes Data Reduction, Data Display, and Conclusion Drawing/Verification. In checking the validity of the findings, this study uses triangulation techniques and member checking.

1. A box contains 16 balls numbered 1 to 16. Two balls are drawn alternately with replacement. Determine which of the following statements is true, and include the proof!
   a) The probability that the ball is a multiple of 4 on the first draw and an even number on the second is $\frac{1}{5}$
   b) The probability that the ball is a multiple of 4 on the first draw and an even number on the second is $\frac{1}{8}$
2. In the box there are 5 silver coins and 4 brass coins. If from the box 2 coins are drawn at random. Determine which of the following statements is true, and include the evidence!
   a) The probability of drawing two coins of different materials is $\frac{5}{9}$
   b) The probability of drawing two coins of different materials is $\frac{7}{9}$
3. The students of class XII MIPA 7 consist of 36 people, a student will be selected who will take part in the scientific writing competition. There are 25 students who like chemistry, 20 students who like biology, and 16 students who like chemistry and biology. Prove that the probability of the student not liking both is $\frac{7}{36}$!

Figure 1. Investigation-Based Problem-solving Test

Table 2. Metacognitive Activities Indicator

Tahap metakognitif	Indikator
Awareness	Students' expressions related to their metacognition indicate awareness to think about: • What is known (knowledge that is related to the task, knowledge that is relevant to the problem, personal strategies that can be used in solving problems) • Position himself in the problem-solving process • What things need, have, and can be done in solving the problem
Evaluation	Student considerations are related to their metacognition which indicates awareness to think about: • The effectiveness and limitations of thought processes • Strategy effectiveness • Assessment of results • Assessment of the level of difficulty of the problem
Regulation	Students' expressions related to their metacognitive processes indicate awareness to think about: • Plan strategy • Develop work steps and goals • Choose the right problem-solving strategy

RESULTS AND DISCUSSION

Result

The participants selected for interviews in the study were coded with S1, S2, and S3, each obtaining a mathematics ability test score of 97.5; 80; and 59. Then categorized sequentially, namely high, medium, and low. The following are the results of investigation-based problem-solving analyzed by metacognitive skills. S1, S2, and S3 metacognitive activities in problem-solving were obtained from test results with a think-aloud method and the transcript of interviews.

1. Understanding the Problem Stage

At the stage of understanding the problem, S1 can understand the problem, which is done by reading the problem to be able to identify what is known and what is asked in the question in detail and correctly, as Figure 2. This finding is in line with the results of think-aloud and the results of interviews.

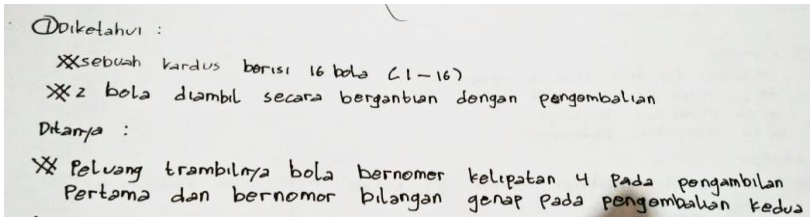

Figure 2. S1 Understanding The Problem 1

The results of think aloud can be seen as follows:

> *Mmmmm... the question is a cardboard box containing 16 balls (1-16), 2 balls taken in turn" (MA). Then what is the chance of being taken by a ball numbered multiple of 4 in the first take and an even number in the second take" (MA).*

While the results of the interview can be seen as follows:

P : How do you understand the problem?
S1 : By reading the problem and then looking for important information on the question (MA)
P : What is the question you received about?
S1 : The question of the chances of 2 incidents of mutual release (MA). Usually, I encounter a question similar to this problem in the math interactive book class XII, Sis. (MA)
P : What information can you know from the problem?
S1 : The information I know is correct (ME), that the information on the question is quite complete (ME) i.e. a cardboard box containing 16 balls numbered 1 to 16 and 2 balls taken in turn with the return (MA)
P : What is the information asked about the question?
S1 : The question is related to probability, It asks to determine the correct statement. The probability of getting a ball numbered 4 on the first draw and an even number on the second draw (MA)

At the stage of understanding the problem, S1 mentions what is known to be a cardboard box containing 16 balls (1-16), 2 balls are taken in turn. Meanwhile, the question is the probability of picking a ball with a multiple of 4 on the first draw and an even number on the second. The results of the answers of participant S1 showed that at the stage of understanding the problem participant S1 used metacognitive activity in solving the problem. S1 used metacognitive awareness and metacognitive evaluation both written and oral.

Participant S1 uses metacognitive awareness activities when she knows how it is done at the stage of understanding the problem, namely by reading the problem and then looking for important information on the problem. Participant S1 knew about the material used, encountered questions similar to the questions done, and was able to reveal what was

known to be a cardboard box containing 16 balls numbered 1 to 16 and 2 balls taken alternately with returns. Participant S1 was able to name what was asked in the form of determining the correct statement about the chances of being taken off a ball numbered multiples of 4 in the first take and an even number in the second take. Meanwhile, S1 used metacognitive evaluation activities to assess the results by believing that the information known was correct and quite complete.

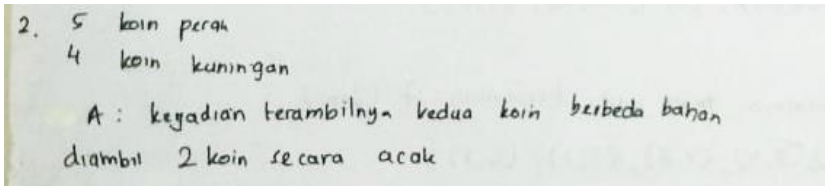

Figure 3. S2 Understanding Problem 2

At the stage of understanding the problem as Figure 3, the participant of S2 is less able to understand the problem. S2 can read the problem and identify what is known, but not the question. Participant S2 mentions what is known to be 5 silver coins and 4 brass coins, then defines $A =$ the event of the taking of the two coins of different materials at random. At the stage of understanding the problem participant S2 uses metacognitive activity in solving the problem. S2 used metacognitive awareness both written and oral. Metacognitive awareness activities used by Participant S2 are in the form of reading problems repeatedly to determine the material and encountering similar questions in HOTS question exercises. S2 can correctly mention the information known to the question in the form of 5 silver coins and 4 brass coins. In this case, the metacognitive awareness given by the participant has not been carried out properly, since participant S2 has not mentioned what was the question.

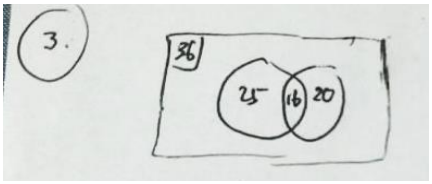

Figure 4. S3 Understanding Problem 3

At the stage of understanding the problem the participant of S3 can understand the problem, which is done by trying to describe a pie chart, however, the figure does not show a clear caption, as in Figure 4. Meanwhile, in the interview results, S3 identified what was asked using clear information. This stage is carried out by S1 as an effort to find answers using metacognitive awareness, both written and oral. S3 uses metacognitive awareness activities by reading the questions and being able to encounter such questions in interactive

books. The participant of S3 was able to identify what was known to be describing a pie chart, but the image did not show a clear caption.

In the interview results, S3 explains clearly what is known in the form of MIPA 7 students consisting of 36 people, 25 students like chemistry and 20 students like biology, and 16 students like both. Then, the question was whether the chances of being selected by students who did not like the subjects were $\frac{7}{36}$.

2. Devising a Plan Stage

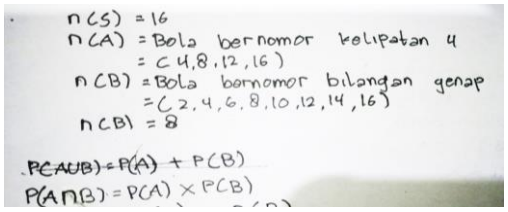

Figure 5. S1 Devising a Plan Problem 1

At the stage of devising the plan, S1 can determine the suitable solving plan and lead to the correct answer to solve the problem, as in Figure 5. S1 can think of a plan by mentioning $n(S)$ =16, $n(A)$ = ball numbered in multiples of 4 $(4, 8, 12, 16)$, $n(B)$ = ball numbered in even $(2, 4, 6, 8, 10, 12, 14, 16) = 4$. S3 can determine the formula to be used in the form of $P(A \cup B) = P(A) + P(B)$. S1 performs metacognitive regulation and metacognitive evaluation, both written and oral.

S1 uses metacognitive regulation when S1 thinks of a plan correctly. As mentioning the number of members of the ball is $n(S)$=16, $n(A) = 4$ for $A = \{4, 8, 12, 16\}$, then $n(B) = 8$ for $B = \{2, 4, 6, 8, 10, 12, 14, 16\}$. Furthermore, to determine the odds, S1 can use the probabilities formula for mutual detachment, namely $(A \cup B) = P(A) + P(B)$. S1 uses metacognitive evaluation by knowing information from reading complete questions. Participant S1 realized the formula used was wrong. S1 confuses about using the probability formula of mutual detachment or whether the probability formula of events was mutually free, and S1 tries to recall the suitable formula. Then S1 uses the probabilities formula of mutually free events, namely $(A \cap B) = P(A) \times P(B)$.

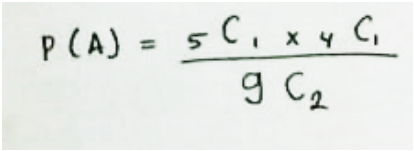

Figure 6. S2 Devising a Plan Problem 2

At the stage of devising the plan, S2 can think of an accurate solving plan and lead to the correct solution. Participant S2 is able to determine the way in which $P(A) = \frac{{}_5C_1 \times {}_4C_1}{{}_9C_2}$, as in Figure 6. his finding is also supported by the results of think-aloud and the results of interviews as follows.

> *"Emmmmm... how about this, oh this has to determine P(A) using calculations* $\frac{{}_5C_1 \times {}_4C_1}{{}_9C_2}$ *"**(MR)**.*

P: How do you think about the steps in solving the problem? Try explaining your method or strategy for solving the problem!
S1: The step I used used used the event odds formula using the combination rule (MR)
P: Why did you choose those steps to solve the problem?
S1: Because I believe that the steps I used are correct (ME)
P: Have you ever changed the formula while working on the problem? Name the reason!
S1: I didn't change the formula I used (ME)

In the stage of devising the plan, S2 performs metacognitive regulation, and metacognitive evaluation, both written and oral. S2 uses metacognitive regulation by using the event probability formula of the combination rule, and S2 uses a plan by determining $P(A)$ and calculating $\frac{{}_5C_1 \times {}_4C_1}{{}_9C_2}$. S2 uses metacognitive evaluation by believing the solution steps are correct and the participant also believes not to change the formula.

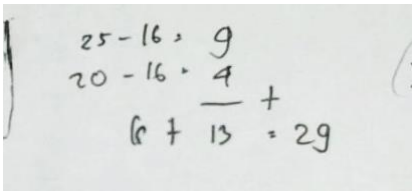

Figure 7. S3 Devising a Plan Problem 3

In the stage of devising the plan, S3 confuses about understanding the given questions. Then S3 understands the question, he can determine the formula to be used, as in Figure 7. S3 finds the solution through metacognitive awareness, metacognitive regulation, and metacognitive evaluation, both written and oral. S3 uses metacognitive awareness activities by trying to re-understand the given questions. S3 uses metacognitive regulation in the form of being able to make plans in the form of $25 - 16 = 9, 20 - 16 = 4,$ and $16 + 13 = 29$. S3 performs metacognitive evaluation by choosing an easy strategy to solve the problem and realizing that he does not use a formula.

3. Implementing The Plan Stage

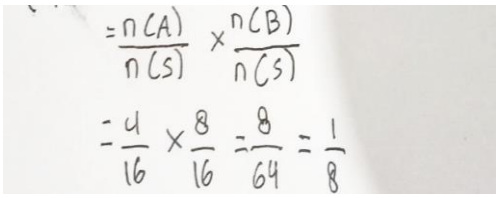

Figure 8. Implementing the Plan of S1 for Problem 1

Based on the results of the answers of S1 at the stage of implementing the plan, S1 applies the strategic plan. S1 performed the correct process and obtained the correct result. S1 carries out a plan in the form of $\frac{n(A)}{n(S)} \times \frac{n(A)}{n(S)} = \frac{4}{16} \times \frac{8}{16} = \frac{1}{8}$, as in Figure 8. S1 finds the solution answers using metacognitive regulation, and metacognitive evaluation. S1 uses metacognitive regulation activities in the form of being able to carry out the right plan using calculations, namely $P(A)\ \frac{n(A)}{n(S)} = \frac{4}{16}$ and $P(B)\ \frac{n(B)}{n(S)} = \frac{8}{16}$**.** Then the value is multiplied $\frac{4}{16} \times \frac{8}{16}$ and get the result $\frac{8}{64}$. Participant S1 uses metacognitive regulation activities in the form of being able to carry out the right plan using calculations, namely, and. Then the value is multiplied and get the result. After which the participant simplifies the value to 1/8. S1 uses metacognitive evaluation by believing that the completion steps are in line, and that the work used is by the previous strategy.

Based on the results of the answers of S2 at the stage of implementing the plan, S2 applies the strategy that has been prepared previously, namely $P(A) = \frac{{}_5C_1 \times {}_4C_1}{{}_9C_2} = \frac{\frac{5\times4}{9\times8\times7!}}{7!\times2\times1} = \frac{5}{9}$, as in Figure 9. The stage of implementing the plan carried out by S2 is finding answers using metacognitive regulation activities and metacognitive evaluation, both written and oral. S2 uses metacognitive regulation activities in the form of realizing the information contained in the problem and determining the correct solution plan in the form $P(A) = \frac{{}_5C_1 \times {}_4C_1}{{}_9C_2}$. In the next step, S2 carried out the plan by previous plan in the form of $\frac{\frac{5\times4}{9\times8\times7!}}{7!\times2\times1} = \frac{5}{9}$. Then, S2 uses metacognitive evaluation by believing that the steps for solving the problem are in order and that S2 does not experience any difficulties.

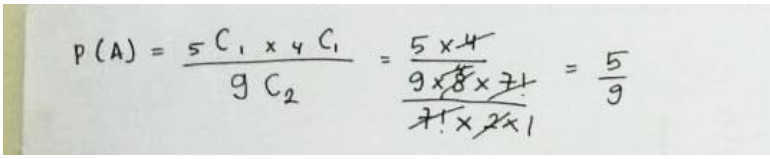

Figure 9. Implementing the Plan of S2 for Problem 2

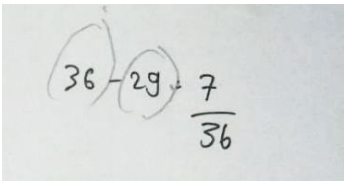

Figure 10. Implementing the Plan of S3 for Problem 3

At the stage of implementing the plan, S3 carries out the plan in a short way but direct to the appropriate answer in the form of, as in Figure 10. This finding is also supported by the results of think-aloud and the results of interviews follows.

Oh this way is $36 - 29 = 7, then\ \frac{7}{36}$ " ***(MR)***

P: What is the problem-solving process you are using?
S1: The process I'm using is 36-29= 7, so 7/36 (MR)
P: Have you ever experienced any difficulty when solving problems? How do you deal with it?
S1: No (ME)

In the stage of implementing the plan, S3 finds the answers using metacognitive regulation and metacognitive evaluation, both written and oral. S3 plans using metacognitive regulation activities in the form of being able to carry out a solving plan by doing calculations correctly, on the formula that has been made $\frac{{}_5C_1 \times {}_4C_1}{{}_9C_2}$, which later produced $\frac{\frac{5\times4}{9\times8\times7!}}{7!\times2\times1} = \frac{5}{9}$. S3 uses metacognitive evaluation activities in the form of believing that the steps used are in order. S3 did not experience any difficulties when completing the problem.

4. Looking Back Stage

At the stage of looking back, S1 can analyze the solution obtained and give a conclusion at the end of the answer with the corresponding result. It turns out that B is correct because the probability of taking the ball is 1/8, as in Figure 11. This finding is in line with the results of think-aloud and the results of interviews. The results of think-aloud can be seen as follows.

"The conclusion on the question is that statement b is correct because the chance of getting the ball is 1/8 (ME). Next, recalculate the answer and check the information known and asked" (ME).

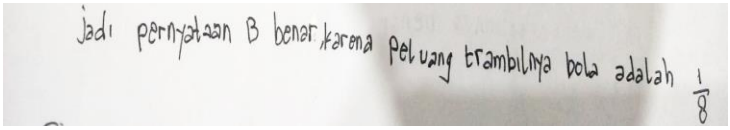

Figure 11. S1 Looking Back Problem 1

The transcript of the interview can be seen as follows:

P: After you finish doing the questions, do you check the answers to the questions?
S1: Yes, I read the question and looked at the answer back (ME)
P: How do you check the answer to the question?
S1: By recalculating the results of the answers I obtained (ME)
P: What information did you get and the steps you used are correct
S1: it is correct, because of the complete reading of the question, (ME)
P: What conclusions did you get from the results of the settlement?
S1: In conclusion, the statement b is correct because the probability obtained is $\frac{1}{8}$ *(ME)*

The stage looking back, S1 uses metacognitive evaluation, both written and oral. The metacognitive evaluation activities emerged by reading the questions and recalculating answers, checking on known and asked information. Participant S1 believes that the information obtained and the steps used are correct. Participant S1 is also able to give a conclusion to the answer in the form of statement b is correct, because the odds of taking the ball are $\frac{1}{8}$. In this case, the participant of S1 can solve the problem using metacognitive evaluation activities by returning the answer to the main objective contained in the problem with the nuances of investigation.

At the stage of looking back, S2 can analyze the solution obtained, and provide a conclusion at the end of the answer. Based on Figure 12, S2 concluded that the true statement is (a). S2 uses metacognitive evaluation activity in form of evaluation, both written and oral. Participant S2 uses metacognitive evaluation activity, namely, the participant gives a conclusion in the form of then the statement below that is true in statement a, and the participant checks the results of the answer by reading the question and looking at the answer again. As well as the participant of S2 believes the steps used are correct.

Participant of S3 did not write down the answer. So that there is no use of metacognitive activity by S3 participants, both written and oral. In the interview results, it was found that at the stage of looking back, S3 could analyze the solution he obtained, and could provide appropriate conclusions at the end of the answer.

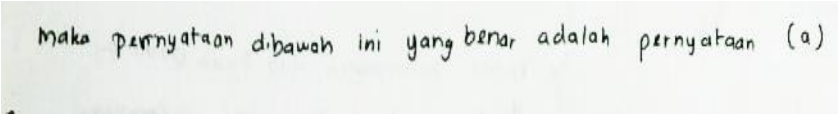

Figure 12. S2 Looking Back Problem 2

Discussion

A successful problem-solving process needs metacognitive activities. In solving problems then involving metacognitive awareness activities, metacognitive regulation, and metacognitive evaluation can support students to succeed in solving problems. This shows that metacognitive skills have an important role in problem-solving (Magiera & Zawojewski, 2011; Wulan et al., 2021). Because with metacognitive awareness in solving problems, a person can understand his knowledge. Then they can solve problems appropriately. Metacognitive activities relate to students' awareness of the participant's knowledge and previous experience in problem-solving, so it is hoped that learning can increase this awareness. The finding resume is presented in Figure 13.

Participant with High Ability

- At the stage of understanding the problem, the participant's metacognitive awareness activities (mentioning what known is and what the question is), and metacognitive evaluation activities (providing an assessment of the results)
- At the stage of devising a plan, the participant's metacognitive regulation activities (able to think of plans correctly), and metacognitive evaluation (believing the effectiveness of strategies, assessment of results)
- At the stage of implementing the plan, the participant's metacognitive regulation activities (can carry out the right plan using calculations), and metacognitive evaluation (provides an assessment of the results)
- At the stage of looking back, the participant's metacognitive evaluation activities (able to return answers to the main objective of questions that are nuanced in an investigation).

Participant with Medium Ability

- At the stage of the understanding problem, the participant's metacognitive awareness activities (mentioning what is known and what is being asked), and metacognitive evaluation activities (not complete by the participant, because the participant has not checked the solution carefully)
- At the stage of devising a plan, the participant's metacognitive regulation (able to think of plans appropriately), and metacognitive evaluation (believing the effectiveness of strategies, and assessment of results)
- At the stage of implementing the plan, the participant's metacognitive regulation activities (can carry out the right plan using calculations), and metacognitive evaluation (provides an assessment of the results)
- At the stage of looking back, the participant's metacognitive evaluation activities (able to return answers to the main objective on questions that are nuanced in the investigation but not on all questions)

Participant with Low Ability

- In the stage of understanding the problem, the participant's metacognitive awareness activities (less able to state what is known and what is asked), and using metacognitive evaluation activities (providing an assessment of the results)
- In the stage of devising a plan, the participant's metacognitive regulation (incomplete by the participant, because the participant cannot think of a strategic plan using the formula), and metacognitive evaluation (choosing an easy strategy and deciding not to use the formula, because the participant understands the problem, but forgets the formula).
- In the stage of implementing the plan, the participant uses metacognitive regulation activities (which are given less by the problem-solving in question), and metacognitive evaluation (provides an assessment of the results that are not appropriate)
- In the stage of looking back, there is no metacognitive activity.

Figure 13. Finding Resume of Participant's Metacognitive Activity

At the stage of understanding the problem, some participants can understand the problem sufficiently, namely being able to identify what information is known and asked. The ability to solve mathematical problems in understanding problems is characterized by

writing down what is known and asking about the problem using their sentences reasonably (Bakker et al., 2021; Smaldino, 2020; Verschaffel et al., 2020). However, some participants are less able to understand the problem. One of the causes of the participant being unable to understand the problem is due to the low level of mathematical knowledge and less using of self-questioning in the metacognitive activity (Kenedi et al., 2019; Lestari, 2018).

At the stage of understanding the problem of the participant S1, S2, and S3 using metacognitive awareness activities by having knowledge related to the task. Such as writing down what is known and asked. In metacognitive awareness, a person needs to realize to think about the position of his knowledge in solving problems processes, what strategies are necessary and suitable, and the relationship between the knowledge possessed and the strategies that can be used (Magiera & Zawojewski, 2011). S2 and S3 are less able to use metacognitive awareness activities because the participants cannot explain the given information clearly. In the learning process, the students do not commonly discuss, convey, and analyze the given information explicitly and synergistically in a text of the problem (Johns et al., 2022; Pulukuri & Abrams, 2021; Stebner et al., 2022)

At the stage of devising the plan, all participants S1, S2, and S3 can determine the appropriate strategic plan. Based on the previous study, before facing the problem, the participant make sure to understand the problem and the determined concept first (Adinda et al., 2021; Ferretti & Caiani, 2019). At the stage of devising the participant's plan, they use metacognitive regulation activities in the form of thinking about a strategic plan for problem-solving appropriately. In metacognitive regulation, the participant can think carefully about making a plan to solve a given problem. In the metacognitive regulation, the participants think and reflect about making a plan to solve the problem (McCord & Matusovich, 2019; Tachie, 2019). Another opinion says that metacognitive regulation is in the form of implementing the right plan, by directly monitoring and working on the strategies that have been thought by paying attention to the information needed to solve the problem (Jusuf, 2018).

S3 used metacognitive regulation that was not suitable for problem. It is because the participant uses his easy steps to solve the problem, lacks an understanding of the problem, and is less able to think of a strategic plan using formulas. In line with the previous research, students are not right in thinking about plans at the stage of solving mathematical problems due to difficulties in understanding problem problems and applying concept. At the stage of

implementing the plan, S1, S2, and S3 use metacognitive regulation by implementing the right plan. The process of applying the plans is by directly working on the strategies. They pay attention to the information needed to solve problems (Jusuf, 2018).

The stage of looking back is carried out by the participant. They re-examined the use of metacognitive activities for answers. However, not all participants understand what to do in reviewing the answers. S1 and S2 participants can write conclusions obtained in the previous step. Students who can write the completion until the fourth step can write the completion well, completely, and correctly (Astutiani, Isnarto, & Isti Hidayah, 2019).

On looking back, especially with the use of metacognitive evaluation, participants S1 and S2 were able to return answers to the main objective of investigation-based problems. They provide conclusions, check the results of the answers by reading the questions and then reviewing the answers, and believe that the steps used are correct, as the previous research (Hidayah et.al., 2022).The activity of metacognitive evaluation contains student expressions related to his metacognitive processes that indicate awareness to think about, plan strategies, draw up work steps and their goals, and choose the right problem-solving strategy (Magiera & Zawojewski, 2011). Meanwhile, the participant of S3 is less able to provide a conclusion to the answer. This is in line with previous research that the frequency of the emergence of metacognitive aspects in problem-solving is influenced by the level of ability possessed by each participant (Kenedi et al., 2019; Lestari, 2018).

CONCLUSION

Students' metacognitive abilities in solving probabilities problem with investigative nuances based on the mathematical abilities of grade 12 students in a high school in Kediri Regency, East Java, Indonesia, in the stage of understanding the problem, metacognitive activity appears in the form of awareness and evaluation. However, the low participant was not able awareness in a good way and the medium participant was not doing a careful evaluation of the results. In the planning stage, the high and medium participants currently use regulation activities by thinking about the right strategy. Evaluation activities, such as believing in the effectiveness of the strategy and assessing the results appropriately. In the stage of implementing the plan, the high and medium participants are using regulation activities by monitoring the planned solutions properly. Evaluation activities are carried out with an appropriate assessment of each result. However, the opposite appeared for low

participant in both previous stages. In the stage of looking back, evaluation activity appears in the form of assessing the suitability of answers to the context of the problem with investigative nuances, but no metacognitive activity was found in low participant. The research abstraction tells the dominant metacognitive activity arises when students solve investigative-based problems in the form of evaluation activities. This activity supports students in assessing concepts, comparing the effectiveness of strategies, and other internal assessments by checking whether the value is wrong or right with the criteria that have been given.

Further research related to how to understand the problem, think of plans, implement plans, and look back by paying attention to metacognitive activities still need exploration. In addition to improving students' ability to solve problems, how students' metacognitive activities at other educational levels and or elsewhere, then other materials still need to be studied. In learning, the teacher should provide questions that can stimulate students to think with their metacognitive activities. It is also necessary to familiarize students with solving problems by following Polya's four steps. This is necessary so that students develop metacognitive activities, and cultivate critical, thorough, and skilled traits in making decisions.

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