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Case Study: Exploration of Numeracy Through a Metacognitive Knowledge Approach

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ABSTRACT

This study explored students' numeracy ability through a metacognitive approach with the Metacognitive Awareness Inventory (MAI) framework. Four female subjects were selected based on their highest scores on cognitive knowledge and cognitive regulation. The three main instruments used and validated by several experts in this study were the MAI questionnaire, problem-solving test, and in-depth interview. This study used purposive sampling to collect data through problem-solving tests and in-depth interview, analyzed based on six indicators of numeracy: understanding the context of the problem, data interpretation, problem solving, reflection and reasoning, mathematical communication, and decision making. The results showed that cognitive regulation supports effective reflection and evaluation, as seen in Subject 3, who solved the problem in a structured and confident manner. In contrast, Subject 4 took longer and often hesitated even though her steps were correct. Subjects 1 and 2, with a focus on cognitive knowledge, excelled in choosing strategies but required additional reflection to ensure accuracy. This study emphasizes the importance of integrating numeracy and metacognitive strategies in learning to improve students' critical and reflective abilities.

Keywords: *Cognitive regulation, metacognition, MAI, numeracy*

Studi Kasus: Eksplorasi Numerasi Melalui Pendekatan Pengetahuan

ABSTRAK

Penelitian ini mengeksplorasi keterampilan numerasi siswa melalui pendekatan metakognitif dengan kerangka kerja *Metacognitive Awareness Inventory* (MAI). Empat subjek perempuan dipilih berdasarkan skor tertinggi mereka pada pengetahuan kognitif dan regulasi kognitif. Tiga instrumen utama yang digunakan dan divalidasi oleh beberapa ahli dalam penelitian ini adalah kuesioner MAI, tes pemecahan masalah, dan wawancara mendalam. Penelitian ini menggunakan *purposive sampling* untuk mengumpulkan data melalui tes pemecahan masalah dan wawancara mendalam, dianalisis berdasarkan enam indikator numerasi: memahami konteks masalah, interpretasi data, pemecahan masalah, refleksi dan penalaran, komunikasi matematis, dan pengambilan keputusan. Hasil penelitian menunjukkan bahwa regulasi kognitif mendukung refleksi dan evaluasi yang efektif, seperti yang terlihat pada Subjek 3, yang memecahkan masalah secara terstruktur dan percaya diri. Sebaliknya, Subjek 4 membutuhkan waktu lebih lama dan sering ragu-ragu meskipun langkahnya benar. Subjek 1 dan 2, dengan fokus pada pengetahuan kognitif, unggul dalam memilih strategi tetapi memerlukan refleksi tambahan untuk memastikan keakuratan. Studi ini menekankan pentingnya mengintegrasikan literasi numerasi dan strategi metakognitif dalam pembelajaran untuk meningkatkan kemampuan kritis dan reflektif siswa.

Kata Kunci: *Metakognisi, numerasi, MAI,* regulasi kognitif

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1. Introduction

Literacy is the ability to read and write demonstrated through understanding simple statements in everyday life. Literacy has a strong relationship with numeracy, which is the ability that involves knowledge, behavior, attitudes, and ability in using mathematics competently in various everyday life situations (Sitompul et al., 2018; Yustitia et al., 2021). The concept of numeracy includes the ability to communicate, interpret, use, and evaluate mathematical information in social, educational, and civic contexts. Literacy and numeracy knowledge are important for students to face the challenges of everyday life (Sumarno et al, 2024). With this ability, students can manage the social environment, make decisions when shopping at the supermarket, and compare prices of various goods effectively. The global economic downturn is partly due to low proficiency in subjects such as science, technology, engineering, and mathematics (STEM). Therefore, literacy and numeracy contribute to the creation of a productive and successful life by facilitating decision-making and management of various aspects of life.

Progress in numeracy depends on students' attitudes toward analytical problem solving and numeracy (Siagian et al., 2019). This ability involves the use of numbers, shapes, and symbols to solve problems according to the needs of society. In practice, numeracy education often involve activities such as graphing and tabulating, which are considered basic abilities for students. To ensure a strong foundation, literacy and numeracy should be taught at the primary and secondary school levels (Fiangga et al., 2019; Lestari et al., 2018; Sumarno et al, 2022). One example is the literacy and numeracy drives which are a top priority in the national education goal (Deeba et al., 2022). This movement focuses on developing children's relational, collaborative, and social ability from an early age. Teachers play an important role in ensuring that students can apply numerical thinking, numerical information, volume, and area in their daily routines.

Students who have good numeracy ability can become citizens who are able to understand statistical information and economic news of a country. They will find it easier to follow world developments through data-based news presented in various media (Musyafak & Agoestanto, 2022). The ability to interpret and critically assess statistical data is essential for informed citizenship in the modern world. This shows that numeracy is not only important in the school environment, but also very relevant in social and economic life, where data and information play a crucial role (Pradika et al., 2019). There are three important aspects of numeracy ability: counting, numerical relations, and arithmetic operations. Numeracy is the basic ability to identify and count the number of objects, both verbally and in writing (OECD, 2022). Numeracy relations involve students' ability to understand quantitative relationships between objects, such as comparisons of greater, smaller, higher, or lower. Meanwhile, arithmetic operations include the ability to complete basic calculations such as addition, subtraction, multiplication, and division. According to the National Council of Teachers of Mathematics, Mastery of basic arithmetic is essential for understanding more complex mathematical concepts later in life (Rachmawati et al., 2022; Santoso & Azizah, 2020; Trisna et al., 2018).

One of the schools in Indonesia that implements the literacy movement is SMAN 3 Sidoarjo. Literacy and numeracy are the focus in efforts to improve the quality of education. As part of the Pioneer School initiative launched by the Ministry of Education, the School participates in the Indonesian School Transformation Program, known as Sekolah Penggerak. This school is committed to developing students' literacy and numeracy competencies holistically, covering cognitive and character aspects. To support the improvement of literacy, SMAN 3 Sidoarjo has carried out various innovations, such as library visit programs and mobile library services that distribute the latest books to students. In addition, the school also encourages students to actively fill the wall magazine with their literacy works. This effort paid off with the award as a National Active Literacy School from Nyalanesia in 2022.

In addition to literacy and numeracy, there are other things that can affect students' cognition, namely metacognition. Metacognitive knowledge is part of the knowledge related to humans as cognitive beings, which includes their tasks, goals, actions, and experiences. Metacognition itself is defined as an individual's ability to "see" their thinking process, involving three main components: planning, monitoring, and evaluation (Santoso & Istiqomah, 2021; Schraw & Moshman, 1995; Shodikin et al, 2022). Metacognitive knowledge can be further divided into three types, namely: (1) declarative knowledge, which focuses on what is known, (2) procedural knowledge, which relates to how to apply certain ability or procedures, and (3) conditional knowledge, which relates to when and why to apply a strategy in a particular context (Laamena & Laurens, 2021; Schraw & Moshman, 1995; Trisna et al., 2018). Meanwhile, regulation of cognition consists of five parts: planning, comprehension monitoring, information management strategies, evaluation, and debugging strategies (Sumarno et al, 2022).

Preliminary research at SMAN 3 Sidoarjo showed that students' understanding of numeracy was at varying levels. Based on the results of classroom observations and brief interviews with mathematics teachers, it was found that most students were able to solve procedure-based numeracy problems but faced difficulties in analyzing and evaluating problems that required critical thinking. For example, 65% of students can solve simple formula-based problems, but only 30% are able to provide a logical explanation of their solution process. These results indicate the importance of a metacognitive knowledge approach in improving numeracy. This approach helps students not only solve problems but also understand their own thinking processes when solving problems. Teachers at SMAN 3 Sidoarjo also stated that the integration of metacognitive strategies in mathematics learning still needs strengthening, especially in encouraging students to reflect on strategies and evaluate the solutions they use.

This finding is relevant to the importance of numeracy in everyday life as mentioned earlier. Numeracy does not only involve basic ability such as using numbers or formulas, but also a deep understanding to apply this knowledge in real situations. Therefore, further exploration through a metacognitive knowledge approach is needed to support students at SMAN 3 Sidoarjo in developing more analytical and applicable numeracy ability.

This study provides an overview of the conditions and levels of numeracy of students at SMAN 3 Sidoarjo. Based on the facts found in the field, it will be described according to the indicators of numeracy based on metacognitive knowledge (OECD, 2017; Prenzel, 2015;

Santoso et al., 2021). The key indicators of numeracy skills used in this study cover a range of essential skills needed to understand and work with numerical information effectively. The first indicator, Understanding the Context of a Problem, refers to the ability to understand a problem in a specific context, such as a real-life situation or a story problem, before attempting to solve it. Data Interpretation involves the ability to read, comprehend, and understand information presented through graphs, tables, diagrams, or numerical formats. The Problem-Solving indicator emphasizes the importance of devising systematic strategies, such as making estimates and verifying results, to solve numerical problems efficiently. Reflection and Reasoning highlight the ability to evaluate the steps taken in solving a problem and to justify the strategies or methods used with logical reasoning. Mathematical Communication focuses on the capacity to express mathematical ideas, strategies, and solutions clearly in oral, written, or visual forms. Finally, Decision Making is the ability to apply numerical information to make meaningful and relevant decisions in everyday life. Together, these indicators form a comprehensive framework for assessing and developing numeracy.

This study aims to develop a deeper understanding of the effectiveness of the metacognitive approach in improving students' numeracy, especially in the context of learning at the high school level. Thus, it is hoped that this study can be a breakthrough in equipping students with more critical, reflective, and applicable numeracy ability to face real-world challenges (Agustan et al., 2017; Syamsuddin et al., 2020). After explaining the importance of numeracy and the role of metacognition in improving these abilities, this study will measure students' numeracy abilities through several indicators. By using these indicators, it is hoped that a clearer picture can be obtained regarding the level of students' numeracy and the extent to which they can apply metacognitive strategies in solving mathematical problems.

2. Method

This study employs a qualitative case study approach with a focus on exploring students' numeracy skills through a metacognitive knowledge perspective. The population consisted of three classes with a total of 108 students. The selection of research subjects was based on the same gender and comparable high mathematical abilities, as indicated by educational report card scores ranging from 93 to 96. Four students were purposively selected as research participants, chosen based on the highest scores in both knowledge and cognitive regulation aspects from the Metacognitive Awareness Inventory (MAI) questionnaire. This purposive selection aimed to obtain participants with strong metacognitive awareness who could provide in-depth insights into the application of metacognitive-based numeracy.

Data was collected using three main instruments: the MAI questionnaire, problem-solving tests, and in-depth interviews. The instruments were validated by experts in mathematics education. The MAI questionnaire was used to assess students' knowledge and metacognitive regulation, which served as the basis for participant selection. The problem-solving test was designed to measure students' ability to solve numeracy problems according to six indicators: understanding the context of the problem, data interpretation, problem solving, reflection and reasoning, mathematical communication, and decision making. In addition, in-depth interviews were conducted to explore students' thinking processes, including the strategies used, the rationale for choosing strategies, and their reflections on problem-solving steps.

This study used purposive sampling to collect data through the problem-solving test and in-depth interviews, analyzed based on the six numeracy indicators mentioned above. To enhance data validity, method triangulation was applied by combining questionnaires, tests, and interviews. This approach was expected to yield comprehensive data on students' numeracy abilities, particularly regarding the application of metacognitive strategies.

3. Results and Discussion

3.1 Results

This study produced in-depth data related to students' numeracy ability based on a metacognitive approach. Based on the results of the Metacognitive Awareness Inventory (MAI) questionnaire, four research subjects, all of whom were female, were selected for further analysis. The subjects were divided into two categories, namely based on knowledge about cognition and regulation of cognition.

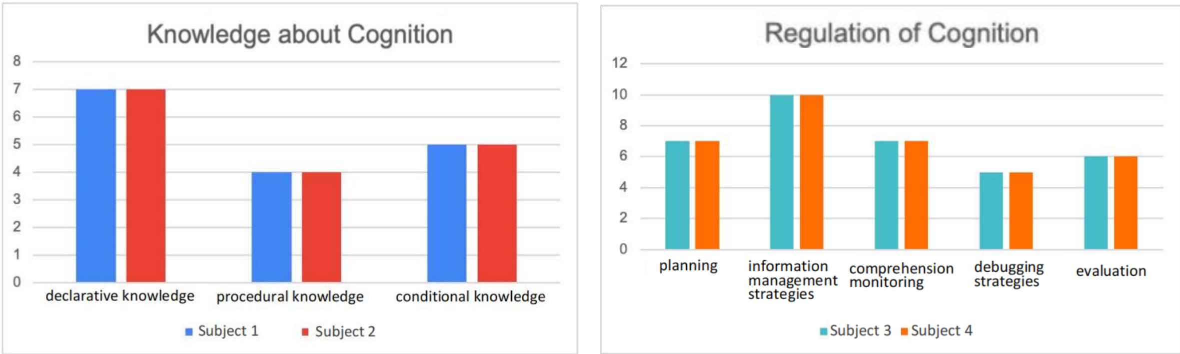

Figure 1. MAI subject questionnaire results

From Figure 1, in the knowledge about cognition category, Subject 1 and Subject 2 obtained the same score on each component, namely 7 on declarative knowledge, 4 on procedural knowledge, and 5 on conditional knowledge. This shows that both subjects have a good level of understanding of what they know, how to apply that knowledge, and when and why to use certain strategies in certain contexts. Meanwhile, in the regulation of cognition category, Subject 1 and Subject 2 also showed identical score patterns on the five components, namely 7 on planning, 10 on information management strategies, 7 on comprehension monitoring, 5 on debugging strategies, and 6 on evaluation. These scores reflect good cognitive regulation abilities in planning, managing, and evaluating their thinking processes.

After this selection process, qualitative data were obtained through problem-solving tests and in-depth interviews. Data analysis focused on numeracy indicators, such as understanding the context of the problem, data interpretation, problem solving, reflection and reasoning, mathematical communication, and decision making with the Metacognitive Awareness Inventory (MAI) framework.

3.1.1 Knowledge about Cognition

Subject 1

Understanding the context of the problem

From a metacognitive perspective, the subject demonstrated strong declarative knowledge, namely an understanding of basic mathematical concepts relevant to the problem. In the first problem (calculating the time to fill a water tank with three taps), the subject understood that each tap had a different flow rate, represented as a fraction of the filling time (e.g., 1/90, 1/80, and 1/60). In the second problem (calculating the percentage of filling a tank), the subject demonstrated the ability to understand the relationship between the operating time of the tap and the volume of water filled. This is in line with the numeracy indicator, namely understanding the context of the problem, where the subject can identify important elements in real situations.

Data interpretation

Data interpretation ability is seen from how the subject reads and understands numerical information, such as the operating time of each tap in the first question and the bacterial data in the second question. With procedural knowledge, the subject can apply the concept of LCM in the first question to align the filling time fractions and calculate the total time. In the second question, the subject uses the proportion of time to full filling to calculate the percentage of volume filled. Both questions show that the subject not only reads the data passively but is also able to use it to build a solution.

Problem solving

Problem solving indicators are supported by planning in metacognition regulation. The subject initially designed a systematic strategy to solve the problem, such as choosing to use the symbol "x" in the first problem to facilitate the calculation of the total filling time. This strategy shows that the subject is aware of the importance of symbolic representation to organize the steps of the solution. In the second problem, the subject quickly chose the strategy of calculating the percentage of water volume filled based on the operating time of the tap.

Reflection and reasoning

Reflection and reasoning are key aspects of the metacognitive approach. Subjects actively monitored the steps they used, especially in the first, more complex problem. They realized initial mistakes, such as adding up the operating time of the tap without considering the flow rate and immediately changing their strategy. In addition, subjects showed the ability to evaluate solutions by comparing the calculation results with the context of the problem, such as interpreting the results of filling an overflowing tank (126.3%) in the second problem.

Mathematical communication

The subject's ability to explain mathematical strategies and solutions orally and in writing reflects indicators of mathematical communication. In the first question, the subject was able to explain the use of the filling time fraction and the steps of calculating the LCM clearly. They also explained the reason for using the symbol "x" to represent the total filling time, which reflects the ability to manage information (information management strategies) in metacognitive regulation. In the second question, the subject explained the process of calculating percentages with easy-to-understand terms, such as "full and overflowing."

Decision making

Decision-making indicators are supported by debugging strategies and evaluation in metacognitive regulation. In the first problem, subjects initially tried the strategy of adding up the operating times of the three taps, but after evaluating that the strategy was inaccurate, they switched to the approach of adding up the flow rates. In the second problem, subjects decided to use percentages as a simpler and more interpretable approach. This shows the subject's ability to adapt the strategy to the needs of the problem.

Subject 2

Understanding the context of the problem

In the first question, Subject 2 was able to understand the context of filling a water tank with three taps that had different filling rates. The subject demonstrated declarative knowledge by recognizing that the problem required calculating the total time based on the filling rate of each tap. Initially, the subject tried to divide the filling time of each tap by three but soon realized that the result was illogical after examining the filling rate of the third tap. This awareness demonstrated a good understanding of the context, supporting the indicator of understanding the context of the problem in numeracy.

Data interpretation

Data interpretation ability is seen in how the Subject uses numerical information, such as 1/90, 1/80, and 1/60, to represent the filling rate of each faucet. With procedural knowledge, the Subject successfully identifies the calculation steps, including adding the filling rate fractions and using the least common multiple (LCM) to align the denominators. In the second problem, the Subject interprets the operating time of the faucets in fractional form, such as 20/90 and 30/80, to calculate the volume filled.

Problem solving

The problem-solving indicator is highly influenced by conditional knowledge, where the Subject decides to use the symbol "y" as a representation of the total time to fill the tub. This strategy makes it easier for the Subject to organize the calculation steps to get the final result, which is 24 minutes 48 seconds. In the second question, the Subject shows a systematic approach by adding up the contribution of each tap to the total volume, then converting the result into a percentage.

Reflection and reasoning

The subject actively reflects his/her thinking process, especially on the first question. The awareness that the initial result (76.6 minutes) is illogical prompts the subject to re-evaluate the strategy used. This demonstrates declarative and conditional knowledge, where the subject is able to recognize errors and choose a more appropriate alternative strategy. On the second question, the subject uses logical reasoning steps to conclude that the result of 126.3% means that the water tank is full (100%) with the rest overflowing.

Mathematical communication

The Subject's ability to convey calculation steps clearly reflects the mathematical communication indicator. The Subject explains the use of fractions to represent the rate of filling the tap and the steps for calculating the LCM up to converting it into time units. In the second question, the Subject is able to describe the calculation results in percentage form and provide a visual interpretation of the condition of the water tank.

Decision making

Subject's decision-making ability is evident from the process of evaluating the strategies used. In the first question, Subject realized that dividing the time by three did not produce a reasonable answer. Subject then decided to use the filling rate per minute approach, which was more accurate. This decision demonstrated the use of conditional knowledge, where Subject understood when and why a particular strategy should be applied.

The results of the study indicate that indicators of numeracy ability and metacognition components complement each other in improving students' ability to solve problems. Subject 1 showed mastery of indicators of understanding the context of the problem, data interpretation, and problem solving, which were supported by declarative and procedural knowledge. Metacognitive regulation, especially planning, monitoring, and evaluation, played an important role in ensuring logical and accurate solutions. However, reflection on simpler questions (second questions) tended to be less in-depth than the more complex first questions. This suggests that subjects need to be encouraged to conduct comprehensive reflection on all types of questions, including questions with a low level of difficulty. Thus, a learning approach that explicitly integrates numeracy and metacognition strategies can help students become more critical, reflective, and applicable in solving real-world context-based problems.

Subject 2 showed good mastery of numeracy indicators, especially in the aspects of understanding the context of the problem, data interpretation, and problem solving. Declarative, procedural, and conditional knowledge in metacognition supported the Subject in choosing and evaluating problem-solving strategies. Metacognitive regulation, such as reflection and evaluation, helped the Subject ensure that the resulting solution was logical and accurate. However, the findings also showed that the Subject tended to focus more on evaluating the calculation steps in the first question compared to the second question. This indicates the need to strengthen reflection strategies at various levels of problem difficulty to improve more consistent numeracy ability. A metacognition-based learning approach can help students like Subject 2 to better understand their own thinking processes and use them effectively in real contexts. Data on the subject of knowledge about cognition can be seen in Table 1.

Table 1. Data about knowledge about cognition

Indicators	Subject 1	Subject 2
Understanding the Context of the Problem	Quickly understands the context and chooses the right strategy from the start.	Understands context after several iterations; takes time to be confident.
Data Interpretation	Thoroughly reads data and immediately relates it to strategy.	Able to read data but sometimes requires reflection to be sure.
Problem Solving	Structured and logical, with an immediately effective approach.	Needs several revisions before arriving at logical steps.
Reflection and Reasoning	Reflects on steps and results in depth to ensure accuracy.	Reflects on steps after realizing inaccuracy of results.
Mathematical Communication	Able to explain steps clearly and in a structured manner.	Explains steps well but only after reaching final solution.
Decision Making	Quickly and accurately choose a strategy without trying other approaches.	Needs further evaluation before changing strategy.

Subject 1 excelled in understanding the context of the problem, problem solving, mathematical communication, and decision making, with a more systematic and confident approach from the beginning. Meanwhile, Subject 2 showed good reflection ability and was able to correct strategic errors, although it took longer to reach an accurate solution. A learning approach that emphasizes early reflection and evaluation can help Subject 2 improve efficiency in understanding the context and solving problems.

3.1.2 Regulation of Cognition

Subject 3

Understanding the context of the problem

In the first question, Subject 3 understood the context of filling a water tank with three different taps. The subject immediately realized that the filling time of more than 60 minutes did not make sense if all three taps were turned on together. This awareness prompted him to modify the approach, using fractions to represent the filling rate of each tap. In this case, the subject showed effective planning, where he re-arranged the strategy after understanding the inconsistency of the initial approach.

Data interpretation

The subject showed good ability in reading and analyzing numerical information. He used fractions such as 1/90, 1/80, and 1/60 to represent the filling rate of each tap, then added them using LCM to align the denominators. The subject also performed partial calculations to ensure the accuracy of the results at each step. This ability reflects good information management strategies in metacognitive regulation.

Problem solving

In the first problem, the Subject successfully solved the problem by calculating the total time it took to fill the tub using the symbol "x" to represent the total time. After cross-calculating, the Subject obtained a result of 24 minutes 48 seconds, but he chose to round the result to 24 minutes to make it easier to interpret. In the second problem, the Subject used a similar strategy to calculate the percentage of water volume filled, resulting in a number of 126%. Both solutions demonstrate good monitoring, where the Subject actively ensures that the calculation steps are running correctly.

Reflection and reasoning

The Subject's reflection is seen from his awareness that the initial result (more than 60 minutes) does not match the condition of the problem. He re-evaluates his approach and chooses a more logical strategy. In the second problem, the Subject realizes that the number 126% means that the water tank is full and overflowing. The Subject demonstrates debugging strategies by revising his initial strategy and ensuring that the result is relevant to the context of the problem.

Mathematical communication

The subject can explain the steps of the solution in a structured manner, including the use of fractions to represent the filling rate and the use of LCM to align the denominators. In the second question, the subject explained the conversion of the calculation results to percentages clearly, although he felt less confident in the result. This shows that the subject can communicate well, although he still needs reinforcement in conveying confidence in the results.

Decision making

In the first question, the subject decided to change the initial strategy after realizing the results were illogical. He chose to use a more accurate fractional approach to calculate the filling rate. In the second question, the subject decided to use the percentage calculation strategy without trying many other approaches, showing confidence in his solution steps. This ability reflects good evaluation in metacognitive regulation.

Subject 4

Understanding the context of the problem

Subject 4 understood the context of filling a water tank with three taps that had different rates. The subject initially felt less confident and doubtful about his calculation steps because he felt he was not careful enough, but after trying several approaches, he managed to identify that the three taps, which flowed at different rates, had to be calculated in the same unit of time (for example per minute). This awareness shows good planning in the problem-solving strategy. Despite initial doubts, the subject then decided to use a comparison of fractions (1/90, 1/80, 1/60) to describe the filling rate of each tap, which is a decision based on declarative knowledge.

Data interpretation

The subject managed to interpret the data correctly, even though he was confused at the beginning. By using good information management, the subject managed to convert numerical information (90 minutes, 80 minutes, 60 minutes) into fractions that could be added. He used LCM to align the denominators, which shows the use of proper procedural knowledge. Subject also utilized debugging strategies by checking calculation steps when the initial result felt illogical.

Problem solving

In the first question, Subject 4 demonstrated thoroughness in managing information and solving problems with careful monitoring. He started with an inaccurate calculation, but immediately corrected his steps using a more logical comparison. After finding a more reasonable result (39 minutes 36 seconds), Subject decided to convert the time to seconds, despite feeling a little unsure about his rounding. This process demonstrated self-evaluation in decision making, despite some uncertainty.

Reflection and reasoning

Subject demonstrated good reflection ability, especially in correcting initial steps that felt inappropriate. When the calculation result did not make sense, Subject reflected and looked for alternative strategies that were more appropriate. This demonstrated effective monitoring and evaluation ability in the metacognition process. In the second question, Subject identified an error in interpreting the question, which initially made him feel doubtful about his answer. However, after reflecting and correcting his approach, Subject felt more confident.

Mathematical communication

The subject can convey his/her mathematical thinking process and steps clearly, despite feeling less confident. The explanation of the use of comparison and LCM shows good mathematical communication ability, although the subject feels that some calculation steps are still not thorough enough. The subject explains the steps in details but sometimes has difficulty believing the result.

Decision making

In the first question, Subject 4 decided to round the result to 39 minutes 36 seconds even though he/she felt a little doubtful. This decision reflects good evaluation, because the subject decided to choose the time closest to the truth after evaluating the result. In the second question, despite the uncertainty in the initial step, the subject decided to continue the calculation using the same method as the first question, which shows that he/she used the same strategy despite some confusion.

Subject 3 showed good mastery of numeracy indicators, especially in the aspects of data interpretation, problem solving, and mathematical communication. Metacognitive regulation, such as planning, monitoring, and evaluation, greatly assisted the Subject in solving complex numeracy problems. However, the Subject showed a lower level of confidence in the second problem compared to the first problem, which may be due to the complexity of interpreting the results in the form of percentages. A deeper metacognition-based learning approach can help the Subject increase his confidence in the results of the solution and strengthen the ability to reflect on all types of problems, both simple and complex. This is important to ensure that students can optimize the potential of metacognitive regulation in various contexts.

Subject 4 shows good regulation of cognition ability, although there was doubt and lack of confidence that emerged throughout the problem-solving process. In planning, the subject managed to start by using fractional comparison, which made the calculation easier. In terms of monitoring and evaluation, although Subject had difficulty interpreting the questions and felt less thorough, he was able to improve his approach and produce more precise answers. Subject 4's main challenge lies in the thoroughness and confidence in evaluating the results, especially when the initial results feel illogical. A learning approach that focuses more on strengthening reflection and self-evaluation can help increase Subject 4's confidence, so that he can feel more confident in each step of his calculations. Overall, although there were some concerns throughout the process, Subject managed to solve the problem in an effective manner. Data on the subject of regulation of cognition can be seen in Table 2.

Table 2. Data on the subject of regulation of cognition

Indicators	Subject 3	Subject 4
Understanding the Context of the Problem	Quickly understand the context of the problem and choose the right strategy from the start.	Takes longer to understand the context and feels less confident.
Data Interpretation	Careful and accurate in reading and processing numerical data (fractions, LCM).	Less thorough at the beginning, often makes revisions, but is ultimately accurate.
Problem Solving	Structured and logical, using clear symbols and steps.	Good completion steps but are often hampered by doubt and correction.
Reflection and Reasoning	Actively reflect on results quickly and confidently.	Reflects on results well but often does so after doubt.
Mathematical Communication	Explain steps clearly, structured, and confidently.	Explains steps well but lacks confidence.
Decision Making	Quickly make decisions when changing inappropriate strategies.	Slow to make decisions due to doubt about the steps taken.

Subject 3 showed more consistent and confident regulation of cognition ability than Subject 4. He was able to understand context, interpret data, solve problems, and make decisions more quickly and in a structured manner. On the other hand, Subject 4 had good reflection and debugging ability, but was often hampered by a lack of precision and confidence, so it took more time to reach the right solution. A metacognition-based learning approach can help Subject 4 increase his confidence and reduce errors due to precision, while

Subject 3 can focus on strengthening reflection strategies to further optimize his understanding.

3.2 Discussion

This study reveals a close relationship between numeracy indicators and metacognitive abilities in subjects. Understanding the context of the problem and interpreting data are proven to be the main basis for solving numeracy problems (Sitompul et al., 2018; Trisna et al., 2018). The knowledge about the cognition aspect (declarative, procedural, and conditional knowledge) helps Subject 1 and Subject 2 understand basic concepts and choose appropriate initial strategies. On the other hand, the regulation of the cognition aspect (planning, information management, monitoring, debugging, and evaluation) allows Subject 3 and Subject 4 to improve strategies and ensure the accuracy of the solution steps (Santoso & Azizah, 2020). The ability to reflect and evaluate is also an important factor in the success of problem solving. Subjects with good reflection and evaluation, such as Subject 3, are able to solve problems confidently and efficiently. In contrast, subjects who are less reflective, such as Subject 2 and Subject 4, take longer to understand the context of the problem or improve the strategy used.

Self-confidence also has a significant influence on performance. Subject 1 and Subject 3, who have high levels of self-confidence, are able to convey the solution steps clearly and in a structured manner. In contrast, the lack of self-confidence in Subject 2 and Subject 4 often causes doubts about the results, even though the solution steps taken are correct. In addition, the complexity of the problem context also affects the difficulties faced by the subjects. Problems with a more complex context, such as the first question, require deeper reflection and strategies than the second question, which has more direct information. This emphasizes the need for effective metacognitive regulation to support students' numeracy at various levels of difficulty.

This study has a comprehensive and holistic approach by integrating numeracy and metacognition dimensions. This approach provides in-depth insight into how students think, analyze, and solve problems (Isnaintri & Novaliyosi, 2024; Tran et al., 2024). The use of numeracy indicators, such as understanding the context of the problem, data interpretation, problem solving, reflection and reasoning, mathematical communication, and decision making, provides a clear structure in analyzing students' abilities. In addition, questions based on real-life contexts, such as filling a water tank and calculating percentages, make it easier for students to connect mathematics to everyday situations, making learning more relevant and applicable. This study also highlights the importance of metacognitive regulation, such as planning, managing information, and evaluating, which have been shown to help students solve numeracy problems effectively.

However, this study has several shortcomings. Limited subject variation, where all subjects have a relatively high ability profile, makes the results difficult to generalize to students with lower numeracy abilities. In addition, focusing on female subjects alone does not fully represent the student population as a whole. This study also has a limited variety of questions, using only two questions, so it does not reflect the various problem-solving strategies in a broader context. Measurement of students' self-confidence was carried out through interviews and subjective observations, which may be less valid than using quantitative instruments. Therefore, further research with a more diverse population, a wider variety of questions, and more objective measurement instruments is highly recommended to strengthen these findings.

4. Conclusion

This study explores students' numeracy ability through a metacognitive approach by reviewing two main dimensions: knowledge about cognition (declarative, procedural, and conditional knowledge) and regulation of cognition (planning, information management, monitoring, debugging, and evaluation). The results of the study on four subjects revealed that students' numeracy ability were greatly influenced by metacognitive aspects. Subjects with good metacognitive regulation, such as planning, monitoring, and evaluation, were better able to solve numeracy problems logically and accurately.

All subjects showed varying mastery of the six numeracy indicators. Understanding the context of the problem and data interpretation became important foundations in developing a solution strategy. Structured and reflective problem solving helped students achieve accurate solutions, while mathematical communication and decision making still needed to be strengthened, especially for subjects who tended to doubt the results of their work. Reflection and evaluation were also key elements of success. Subjects with good reflection ability (Subject 3) were more confident in solving problems. On the other hand, the lack of reflection at the beginning of the process (Subject 4) often led to inappropriate steps and required revision. Self-confidence also plays an important role. Confident subjects (Subject 1 and Subject 3) were more efficient in choosing strategies and solving problems, while doubts (Subject 2 and Subject 4) often slowed down the solution process even though the steps taken were correct. In addition, the complexity of the problem affects the difficulties faced by students. Problems with more complex contexts require higher metacognitive regulation, such as strategy evaluation and in-depth reflection, while simple problems tend to encourage less student reflection. This study emphasizes the importance of integrating numeracy with a metacognitive approach in learning. This approach helps students not only understand and solve problems, but also trains them to reflect on their thinking processes, make the right decisions, and increase their self-confidence. Learning strategies based on reflection, evaluation, and mathematical communication are highly recommended to strengthen students' numeracy ability in facing real-life challenges.

5. References

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