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Students' Metacognitive Awareness in Mathematics Learning

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ABSTRACT

Understanding students' level of metacognitive awareness in the process of learning mathematics can assist them in developing their metacognitive abilities and enhancing their mathematical comprehension. Through this research, students' metacognitive awareness is analyzed so that educators can design and develop more effective teaching strategies to address students' difficulties in solving mathematical problems. This study is a descriptive quantitative research conducted to describe the metacognitive awareness of students in the Mathematics Education Study Program at the University of Nias involving a total of 58 students. The data collection technique employed in this research is through the Metacognitive Awareness Inventory (MAI) questionnaire. The research findings indicate that metacognitive awareness measured from the cognitive regulation aspect obtained higher scores compared to metacognitive knowledge. In terms of metacognitive knowledge aspect, the highest statement values related to procedural knowledge processes, indicating that students have specific goals for each strategy they use, while the lowest values were found in declarative knowledge processes, stating that students are adept at organizing information. The smallest overall percentage value in the assessment of metacognitive awareness is associated with statements such as slowing down when finding important information and using pictures or diagrams to aid understanding while learning.

1. Introduction

Mathematics is commonly perceived as a challenging subject by many students. Numerous learners encounter difficulties in solving complex mathematical problems. Therefore, the presence of metacognitive awareness among students is necessary in tackling these complex mathematical problems within the realm of mathematics learning. Metacognition involves thinking about thinking, as expressed by Livingston (2003), who defines it as the process of thinking about thinking. The term "Metacognitive" was first introduced by John Flavel in 1979. Metacognition plays a crucial role in acquiring information, understanding problems, finding solutions, and self-regulation. In this context, students process all information by contemplating whether the information received is correct or not. This thinking activity contributes to students' increasing confidence in learning, especially during the process of learning mathematics.

Furthermore, Masoodi (2019) asserts that metacognition relates to theory of mind, which is the ability to understand one's own mental state. Novia et al. (2019) state that metacognition is a fundamental ability that students must possess and develop as it represents a crucial indicator in teaching. Moreover, Tak, Zulnaidi, & Eu (2022) also suggest that students with high self-confidence and metacognitive awareness significantly influence students' reasoning abilities.

According to Panchu, Bahuleyan, K., & Thomas (2016), metacognitive awareness is a crucial aspect in the learning process, not only for elementary and middle school students but also for higher levels. Students' metacognitive awareness in the process of learning mathematics supports their understanding of effective learning methods, the extent of their problem-solving abilities in mathematics, and the appropriate strategies for solving mathematical problems. This metacognitive awareness influences the utilization of cognitive abilities to be more effective and efficient in resolving issues (Wilson & Conyers, 2016).

According to Flavell (1979), metacognition consists of metacognitive knowledge and regulation or metacognitive experiences. Metacognitive knowledge refers to an individual's understanding of metacognitive concepts, such as their comprehension of learning strategies, ability to monitor their own understanding, and knowledge of the learning process itself. Regulation or metacognitive experiences encompass an individual's practical experience in organizing, managing, and controlling their thinking processes and learning. This includes the ability to plan learning, monitor comprehension, evaluate learning strategies, and overcome learning obstacles or difficulties.

Schraw and Dennison (1994) and Tak, Zulnaidi & Eu (2022) revealed that metacognitive knowledge comprises three processes: declarative knowledge, procedural knowledge, and conditional knowledge. Declarative knowledge involves facts, concepts, or information related to self-understanding in the context of learning or problem-solving. Procedural knowledge is understanding the steps or strategies on how to do something, such as steps to solve a problem or learning tasks. Conditional knowledge pertains to understanding specific conditions or contexts that influence the use of procedural knowledge in certain situations or contexts.

The metacognitive experience or regulation consists of five process components: planning, information management strategies, comprehension monitoring, debugging strategies, and evaluating. Planning involves the process of planning or pre-planning before starting a specific task or learning. Information management strategies are methods for managing the necessary information acquired during the learning process. Comprehension monitoring is the process of monitoring understanding of the material or task being studied. Debugging strategies involve efforts to address problems or errors in comprehension or learning strategies. Evaluation is the process of re-evaluating learning outcomes or the learning process itself.

Additionally, Wardana et al. (2021) suggest that metacognitive awareness can be measured by the aspects of metacognitive knowledge and cognitive regulation processes. Besides its association with academic achievement, metacognitive abilities enable students to succeed in completing their tasks. However, some research indicates that some students have limited metacognitive awareness in mathematics learning. They might not be aware of strategies supporting effective learning, fail to monitor their understanding adequately, or struggle to regulate and organize their thinking when solving mathematical problems.

Analyzing students' metacognitive awareness in mathematics learning is essential. Understanding the level of students' metacognitive awareness allows educators to design appropriate teaching strategies to help students develop their metacognitive abilities and improve their mathematical understanding. According to AlAli, Wardat & Al-Qahtani's research (2023), metacognitive thinking can be enhanced through the SWOM (School Wide Optimum Mode) strategy. SWOM strategy is a recent trend in teaching thinking skills and integrating them into learning content aiming to enhance learning and outcomes in preparing a generation with comprehensive, critical, and creative thinking awareness. Additionally, in STEAM (science, technology, engineering, arts, and mathematics) learning, students' metacognitive awareness tends to be higher than those in traditional learning methods (Wahba, Tabieh & Banat, 2022).

This analysis will involve researching students from the Mathematics Education program to evaluate their metacognitive awareness in mathematics learning. Data will be collected through a metacognitive awareness questionnaire to obtain comprehensive insights into students' metacognitive awareness. By understanding students' level of metacognitive awareness in the mathematics learning process, this research can provide valuable insights for educators and curriculum development. Through a solid understanding of students' metacognitive awareness, educators can design more effective teaching strategies to assist students in overcoming difficulties in solving mathematical problems.

2. Method

This research method utilizes a quantitative descriptive approach. The aim is to describe the Metacognitive Awareness of students enrolled in the Mathematics Education Program at the University of Nias, involving a total of 58 students. The data collection technique employed is through the administration of the Metacognitive Awareness Inventory (MAI) questionnaire, adapted from the work of Gregory Schraw & Dennison (1994). This questionnaire comprises 52 closed-ended statements encompassing aspects of metacognitive knowledge (declarative, procedural, and conditional) and metacognitive experience or regulation (planning, information management strategies, comprehension monitoring, debugging strategies, and evaluating).

The statements are for Declarative Knowledge consisting of: 1) I understand my intellectual strengths and weaknesses, 2) I know what kind of information is most important to learn, 3) I am good at organizing information, 4) I know what the teacher expects me to learn, 5) I am good at remembering information, 6) I have control over how well I learn, 7) I am a good judge of how well I understand something, 8) I learn more when I am interested in the topic.

The statements are for Procedural Knowledge consisting of: 1) I try to use strategies that have worked in the past, 2) I have a specific purpose for each strategy I use, 3) I am aware of what strategies I use when I study, 4) I find myself using helpful learning strategies automatically.

The statements are for Conditional Knowledge consisting of: 1) I learn best when I know something about the topic, 2) I use different learning strategies depending on the situation, 3) I can motivate myself to learn when I need to, 4) I use my intellectual strengths to compensate for my weaknesses, 5) I know when each strategy I use will be most effective.

Then, the statements are for Planning consisting of: 1) I pace myself while learning in order to have enough time, 2) I think about what I really need to learn before I begin a task, 3) I set specific goals before I begin a task, 4) I ask myself questions about the material before I begin, 5) I think of several ways to solve a problem and choose the best one, 6) I read instructions carefully before I begin a task, 7) I organize my time to best accomplish my goals.

The statements are for Comprehension Monitoring consisting of: 1) I ask myself periodically if I am meeting my goals, 2) I consider several alternatives to a problem before I answer, 3) I ask myself if I have considered all options when solving a problem, 4) I periodically review to help me understand important relationships, 5) I find myself analyzing the usefulness of strategies while I study, 6) I find myself pausing regularly to check my comprehension, 7) I ask myself questions about how well I am doing while learning something new.

The statements are for Information Management Strategies of: 1) I slow down when I encounter important information, 2) I consciously focus my attention on important information, 3) I focus on the meaning and significance of new information, 4) I create my own examples to make information more meaningful, 5) I draw pictures or diagrams to help me understand while learning, 6) I try to translate new information into my own words, 7) I use the organizational structure of the text to help me learn, 8) I ask myself if what I'm reading is related to what I already know, 9) I try to break studying down into smaller steps, 10) I focus on overall meaning rather than specifics.

The statements are for Debugging Strategies of: 1) I ask others for help when I don't understand something, 2) I change strategies when I fail to understand, 3) I re-evaluate my assumptions when I get confused, 4) I stop and go back over new information that is not clear, 5) I stop and reread when I get confused.

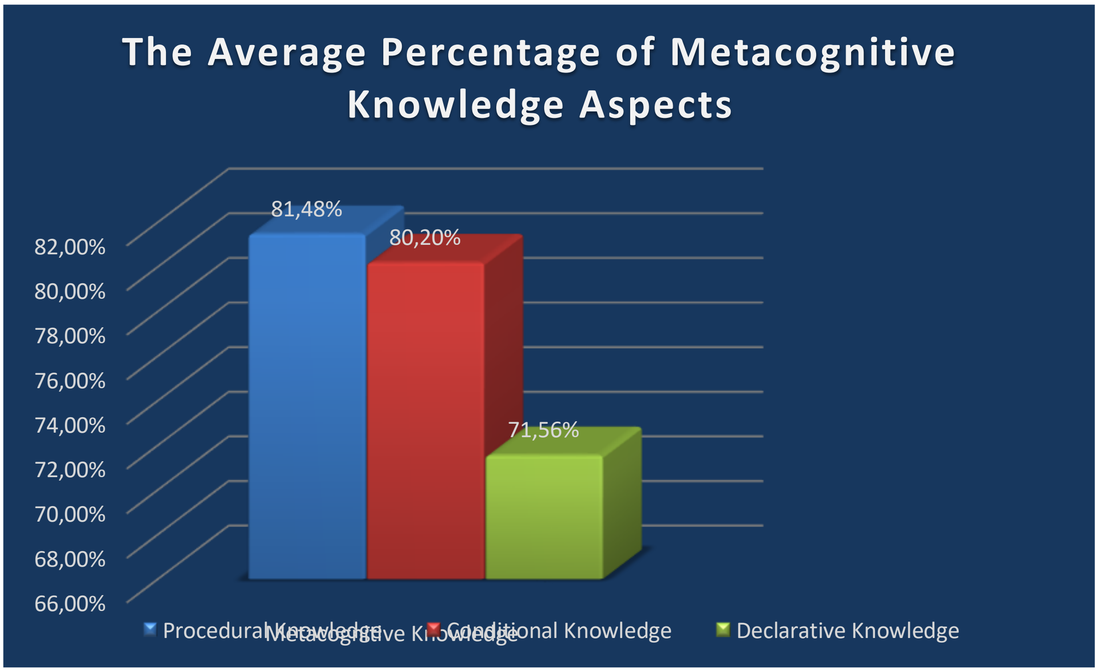
Then, the statements are for Evaluation of: 1) I know how well I did once I finish a test, 2) I ask myself if there was an easier way to do things after I finish a task, 3) I summarize what I've learned after I finish, 4) I ask myself how well I accomplish my goals once I'm finished, 5) I ask myself if I have considered all options after I solve a problem, 6) I ask myself if I learned as much as I could have once I finish a task.

Each statement in the questionnaire offers two answer choices: true or false. Respondents select true if they have experienced the statement and false if they have not. A correct response receives a score of 1, while an incorrect response is scored as 0. Data analysis involves computing total scores and percentages for each statement. These calculations are then detailed per aspect and indicator to derive a comprehensive conclusion.

3. Result and Discussion

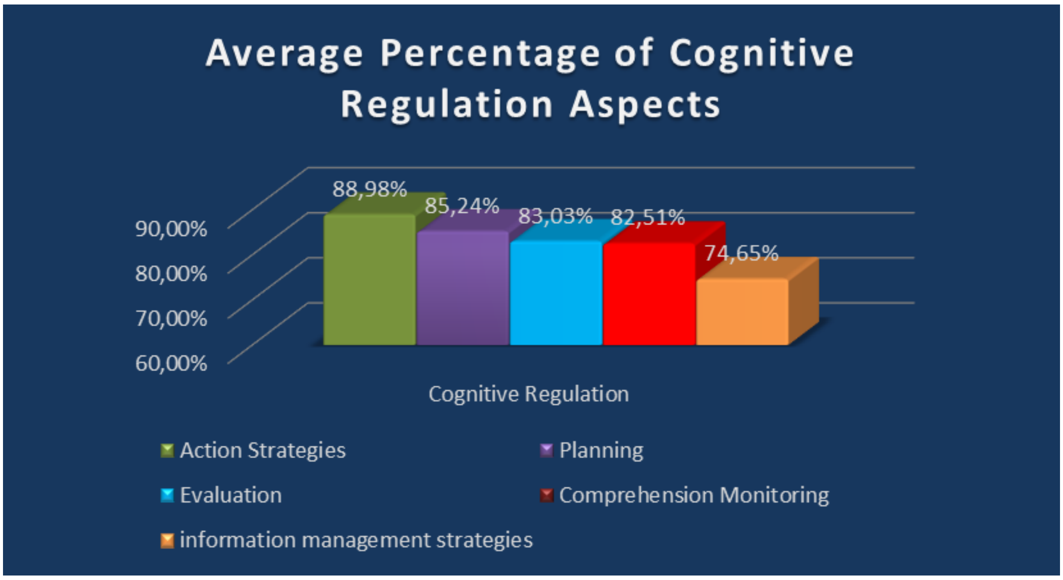
Overall, metacognitive awareness measured through the cognitive regulation aspect obtained higher scores than metacognitive knowledge. Cognitive regulation had an average percentage of 82.88%, while metacognitive knowledge had an average percentage of 77.75%. Within the metacognitive knowledge aspect, procedural knowledge had the highest average percentage score at 81.48%, followed by conditional knowledge with a score of 80.2%, and the lowest was declarative knowledge with a score of 71.56%. These aspects of metacognitive knowledge are also illustrated in Graphic 1 below.

Graphic 1. The Average Percentage of Metacognitive Knowledge Aspects



In aspects of cognitive regulation obtained values from the highest to the lowest, namely action strategies (debugging strategies) by 88.98%, then planning (including planning) by 85.24%, evaluation (evaluating) by 83.03%, comprehension monitoring (comprehention monitoring) by 82.51%, and information management strategies (information management strategies) by 74.65%. Aspects of cognitive regulation is also shown in Graphic 2 below.

Graphic 2. Average Percentage of Cognitive Regulation Aspects



From all aspects of metacognitive awareness assessment, in terms of cognitive regulation, statements where students consider several alternatives to a problem before responding, as well as statements where students seek help from others when they do not understand something, have the highest percentage scores at 98.3% each.

When viewed from each aspect of metacognitive knowledge processes, the highest and lowest values for each indicator are delineated. In the declarative knowledge process, the highest value is obtained from the statement that students learn more when interested in the topic, with a score of 91.4%. Meanwhile, the lowest value is associated with the statement that students are skilled in organizing information, scoring 46.6%.

Regarding procedural knowledge processes, the statement indicating that students have specific goals for every strategy they use has the highest score at 96.6%, while the lowest value is attributed to the statement that students know how to use beneficial learning strategies automatically, scoring 67.2%.

In the conditional knowledge process, the highest value is associated with the statement that students learn well when they have some prior knowledge about the topic, scoring 89.7%. Conversely, the smallest value is linked to the statement that students know when each strategy they use will be most effective, scoring 70.7%.

Moreover, within the regulation process, there are five components: planning, with the highest value attributed to the statement that students carefully read instructions before starting a task, scoring 96.6%. Conversely, the lowest value is linked to the statement that students ask themselves questions about the material before starting to study it, scoring 70.7%.

In the information management process, the highest value is associated with the statement that students consciously focus their attention on important information, scoring 94.8%. Conversely, the lowest value is attributed to the statement that humans create their own examples to make information more meaningful, scoring 67.2%.

Finally, in the comprehension monitoring process, the highest value is attributed to the statement that students consider several alternatives to a problem before responding, with a high score of 98.3%. The lowest value is linked to the statement that students can analyze the usefulness of strategies when they learn, scoring 65.5%.

In the action strategy process (debugging strategies), the highest score is obtained from the statement where students seek help from others when they do not understand something, scoring 98.3%. The lowest score is associated with the statement where students stop and reread unclear new information, scoring 82.8%.

In the final process, the aspect of evaluation, the statement with the highest score is where students ask themselves if there is an easier way to do something after completing a task, scoring 91.4%. The lowest score is linked to the statement where students summarize what they have learned after finishing, scoring 74.1%.

Based on the data obtained from the research results, it indicates that individuals' awareness or ability to regulate, plan, monitor, and evaluate their own learning processes tends to be higher than their understanding of metacognitive concepts. It also suggests that individuals' understanding of metacognitive concepts, such as comprehension of learning strategies or understanding learning conditions, tends to be slightly lower than their ability to manage the learning process.

4. Conclusion

Overall, metacognitive awareness measured through cognitive regulation aspects obtained higher average scores compared to metacognitive knowledge. Among all aspects assessing metacognitive awareness, the highest values lie in the cognitive regulation aspect, specifically in statements where students consider several alternatives to a problem before responding and seek help from others when not understanding something. These statements received the highest percentage scores. Conversely, the lowest percentage values overall in assessing metacognitive awareness relate to statements where students slow down when encountering crucial information and when they draw or create diagrams to aid their understanding while learning. This also illustrates the values specifically within the cognitive regulation aspect.

In terms of metacognitive knowledge processes, the highest value is associated with procedural knowledge, particularly in the statement where students have specific goals for every strategy they use. On the other hand, the lowest value in declarative knowledge processes is linked to the statement where students are skilled at organizing information.

Based on these descriptions, this research indicates that respondents tend to have better skills in applying cognitive regulation strategies (metacognitive experiences) in organizing and managing their learning compared to their understanding of metacognitive concepts themselves (metacognitive knowledge). There is potential to strengthen their understanding of metacognitive concepts to enhance their overall metacognitive awareness, complementing their already strong cognitive regulation abilities. This enhancement could lead them to become more effective and independent learners. In the context of learning, these findings can be utilized to adjust learning strategies. It's crucial to focus on developing an understanding of metacognitive concepts while still emphasizing the development of management and regulation skills in the learning process.

Based on the findings of the study which indicate differences in metacognitive aspects such as cognitive awareness and metacognitive knowledge, as well as the tendency of respondents to apply cognitive regulation strategies, there are several suggestions for future research: 1) Focus on Metacognition Development; Further research can be focused on developing students' or respondents' metacognition. This could involve developing specific educational programs or interventions designed to enhance their understanding of deeper metacognitive concepts. 2) Interventions in Learning; Investigating the effectiveness of educational interventions focused on improving understanding of metacognitive concepts, for example with the use of teaching strategies or learning techniques specifically aimed at increasing awareness of metacognitive processes; 3) Use of Metacognitive Measurement Tools; 4) developing or using new, more sensitive and specific measurement tools to measure metacognitive components, both in terms of cognitive awareness and metacognitive knowledge, to gain a deeper understanding of the differences between the two; 5) Comparative Studies; conducting comparative studies between groups of students or individuals who have high metacognitive knowledge and those who have high cognitive awareness, to understand the differences in their learning strategies and how the use of these strategies affects their learning outcomes; 6) Implementation in the Learning Environment; 7) Implementing these findings into the actual learning environment, such as adopting learning strategies that can improve the understanding of metacognitive concepts while still strengthening students' cognitive regulation abilities; 8) Developing Learning Resources; Building educational resources or materials that focus on metacognitive understanding, which can be used by students, educators, or educational institutions in supporting more effective learning. Future research can explore these areas to better understand the dynamics between cognitive awareness and metacognitive knowledge and how developing both can help improve overall student learning outcomes.

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6. References

AlAli , R., Wardat, Y. & Al-Qahtani, M, (2023). SWOM Strategy and Influence of its Using on Developing Mathematical Thinkingnskills and on Metacognitive Thinking Among Gifted Tenth-Grade Students. EURASIA Journal of Mathematics, Science and Technology Education,19(3).

Bannert, M., Hildebrand, M. & Mengelkamp, C, (2009) “The Effects of Learning Strategies Instruction on Metacognitive Knowledge, Using Metacognitive Skills and Academic Achievement (Primary Education Sixth Grade Turkish Course Sample,”.

Masoodi, M. (2019). An Investigation into Metacognitive Awareness Level: A Comparative Study of Iranian and Lithuanian University Students. The New Educational Review, 148–160.

Novia, H., Kaniawati, I., Rusli, A., & Rusdiana, D. (2019). The Development of Metacognitive Awareness Related to the Implementation of Metacognitive-based Learning. Journal of Physics: Conference Series

Flavell, J. H. (1979). Metacognition And Cognitive Monitoring: A New Area Of Cognitive Developmental Inquiry. American Psychologist, 34(10), 906.

Livingston, J. A. (2003). Metacognition: An Overview.

Panchu, P., Bahuleyan, B., K, S., & Thomas, T. (2016). Metacognitive Awareness-Eavaluation and Implications in Medical Students. International Journal of Research in Medical Sciences, 4(8), 6012.

Schraw, G., & Dennison, R. (1994). Assessing Meta-Cognitive Awareness. Contemporary Educa-Tional Psychology Development Of The Comprehensive Learning, 19, 460-475.

Tak, C.C., Zulnaidi, & Eu. (2022). Measurement model testing: Adaption of self-efficacy and metacognitive awareness among university students. EURASIA Journal of Mathematics, Science and Technology Education, 18(9)

Wahba, F.A., Ahmad A. S. Tabieh, A.A.S., & Banat, Y.S. (2022). The power of STEAM activities in enhancing the level of metacognitive awareness of mathematics among students at the primary stage. EURASIA Journal of Mathematics, Science and Technology Education, 18(11).

Wardana, R.W., Prihatini, A & Hidayat, M (2021). Identifikasi Kesadaran Metakognitif Peserta Didik dalam Pembelajaran Fisika. PENDIPA Journal of Science Education. 5(1), 1-9

Wilson, D. D., & Conyers, M. (2016). Teaching Students To Drive Their Brains: Metacognitive Strategies, Activities, And Lesson Ideas. Usa: Ascd.