Literature Review: The Relationship between Metacognitive Abilities and Student Learning Outcomes in Mathematics Learning

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ABSTRACT

Metacognitive abilities play a crucial role in helping students organize, monitor, and control their thinking processes during mathematics learning. These abilities enable students to understand their learning process more consciously, choose appropriate strategies, and evaluate errors that arise during problem-solving. However, students' low metacognitive awareness remains a contributing factor to poor mathematics learning outcomes. Based on these conditions, this study aims to analyze the relationship between metacognitive abilities and student learning outcomes, review trends in previous research results, and provide a general overview of research findings related to mathematics learning. This study used a Systematic Literature Review (SLR) approach by examining 20 articles published between 2015 and 2025. The results indicate a positive and significant relationship between metacognitive abilities and mathematics learning outcomes. Furthermore, previous research trends demonstrate a consistent pattern of findings, namely that increased metacognitive abilities are associated with improved student learning outcomes. These findings demonstrate the importance of strengthening metacognitive aspects in mathematics learning.

Keywords: *Metacognitive Ability, Learning Outcomes, Mathematics, SLR.*

1) INTRODUCTION

Education is a systematic effort to develop the potential of students to be able to think critically, creatively, and independently (Wati & Sari, 2023). In the context of education in Indonesia, mathematics is one of the main subjects that has great potential to develop students' critical thinking skills and creativity (Hidayati et al., 2025). The role of mathematics in developing a person's thinking ability makes mathematics a means that plays an important role in developing science and technology. Through mathematics learning, students are not only expected to understand the material taught, but also to be able to develop reasoning, communication, representation, and problem-solving skills (Siswanto, 2024).

However, some previous studies such as research conducted by Rosdianah et al. (2019), shows that almost every student considers mathematics subjects to be difficult subjects, so that the lack of motivation in learning mathematics ultimately has an impact on the low learning outcomes of students in mathematics subjects. Report Programme for International Student Assessment (PISA) in 2022

also shows that the average mathematics score of Indonesian students was recorded at 366, far below the average of OECD countries which reached 472 points (OECD, 2023). This indicates that students do not have adequate abilities to understand, interpret, and apply mathematical concepts contextually to solve mathematical problems. This condition has an impact on the low mathematics learning outcomes obtained by students.

One of the factors that contribute to the low learning outcomes of mathematics is the learning approach that is still procedural and teacher-centered. Research from Mahajani et al. (2024) It was found that many students still focus on procedural completion without understanding the concepts of the material, so that students' critical and creative thinking skills are limited. In line with that research Cahyani et al. (2022); Fariz et al. (2023) stated that in mathematics learning, students often experience difficulties in identifying important information, formulating strategies, and evaluating the solutions obtained. This limitation is closely related to the weak ability of the individual to realize and manage his own thought processes or which is the basis of metacognition.

Metacognition is the ability of an individual to be aware, control, and reflect on his or her own thought process. In general, metacognition ability can be understood as a person's ability to think about his or her own thought process (Lebuda & Benedek, 2023). Metacognition ability plays a role in increasing the effectiveness of mathematics learning (Safitri et al., 2020). In line with that research Sukiyanto, (2020) Stating that metacognition skills play an important role in helping students plan completion steps, monitor understanding during the learning process, and evaluate the effectiveness of the strategies used.

Although various studies have shown the important role of metacognition abilities, their implementation in the classroom is still not optimal. Many teachers do not fully understand how to cultivate students' metacognitive awareness during learning. The focus of learning is still dominant on the final result, not on the thinking process that students go through. As a result, students are not used to reflecting on their understanding and do not yet have control over their own learning process (Patmah, 2024).

Based on the above background, the purpose of this study is to analyze the relationship between metacognition abilities and students' learning outcomes in mathematics learning. Through this study, it is hoped that it can provide a clear picture of the extent to which metacognition skills play a role in improving students' mathematics learning outcomes. The results of this analysis can also be a reference

for researchers and future researchers in studying topics related to students' metacognition abilities in mathematics learning.

2) METHODS

The method used in this study is a systematic review of literature (Systematic Literature Review). Systematic literature review (SLR) is a systematic research method for collecting, critically evaluating, integrating, and presenting findings from various research studies on research questions or topics of interest (Dia et al., 2023). The data used in this study are secondary data obtained indirectly through the results of previous research that have been published in various scientific journals. The stages in the research Systematic Literature Review (SLR) according to Nova, (2022) It covers several key steps, namely:

a. Research Question

This stage begins by compiling questions as a reference for searching, selecting, and analyzing the literature data of research questions. Research Questions are created based on the needs of the chosen topic. This study aims to identify and analyze the relationship between metacognition abilities and students' learning outcomes in mathematics learning. Therefore, some of the research questions that are the focus of this study are as follows:

1. RQ1. What is the relationship between metacognition skills and student learning outcomes in mathematics learning?
2. RQ2. What is the tendency of research results that discuss the relationship between metacognition abilities and student learning outcomes?
3. RQ3. What are the types of research used in previous studies to examine the relationship between metacognition abilities and student learning outcomes in mathematics learning?

b. Search Process

The article search process in this study is sourced from accredited and peer-reviewed journal publications, both in Indonesian and English, published in the last 10 years to ensure the relevance and novelty of the data and relevance to the predetermined research questions (RQ).

c. Inclusion and Exclusion Criteria

At this stage, it is decided whether or not the data found can be used in SLR research. The feasibility study is carried out assuming that the following conditions have been met:

1. Relevant information was found in the last 10 years.
2. Information was obtained through national and international journal databases such as Google Scholar, Garuda, ScienceDirect, and Scopus.
3. The information used is only related to the relationship between metacognition abilities and students' learning outcomes in mathematics learning.

d. Quality Assessment

Quality Assessment (QA) is created from a list of previously identified problems. This QA must include an evaluation to answer each problem formulated. In this study, the data found will be assessed using quality assessment criteria which include the following questions:

1. QA1: Does the article discuss the relationship between metacognition abilities and learners' learning outcomes in mathematics learning?
2. QA2: Does the article present any results or findings that illustrate the relationship between metacognition abilities and learners' learning outcomes?
3. QA3: Does the article clearly explain the type of research used in examining the relationship between metacognition abilities and learners' learning outcomes?

Each article will be judged based on these two criteria with the following assessment categories:

AND (Yes) : If the article is relevant and meets the criteria for the question.

T (No) : If the article is irrelevant or doesn't meet the question criteria.

3) RESULTS AND DISCUSSION

Results

This *Systematic Literature Review* (SLR) research was conducted to identify various research results that discuss the relationship between metacognition abilities and students' learning outcomes in mathematics learning. The time range used in this literature analysis is the last 10 years, i.e. from 2015 to 2025, to ensure that the articles reviewed are relevant and current publications. Data was collected from various sources such as Google Scholar, Garuda, Science Direct, and Scopus. The information

included is only related to research that discusses metacognition abilities, learning outcomes, and mathematics learning.

From the initial search results, 15 relevant articles were found through the use of keywords such as "metacognition ability in mathematics learning", "mathematics learning outcomes", and "the relationship between metacognition ability and student learning outcomes". In the initial stage, a review of the title was carried out to conduct an initial selection. The researcher ensures that each article title is related to the focus of the research.

In the next stage, the researcher conducts a selection based on abstracts to assess the suitability of the content of the article with the research topic. From this process, some articles were eliminated because they did not directly address the relationship between metacognition abilities and learning outcomes, while relevant articles were retained for further analysis.

Furthermore, the selected articles were grouped based on the characteristics of the research, such as the method used, the level of education of the students, and the focus of research related to metacognition abilities and learning outcomes in mathematics learning. This grouping is carried out to facilitate the analysis process and compare similar research results, so that an overview can be obtained of the variety of approaches and research contexts that discuss the relationship between metacognition abilities and student learning outcomes.

In the final stage, a Quality Assessment (QA) is carried out to ensure that the articles used meet the research criteria. 20 main articles were obtained that were declared feasible because they met the requirements for relevance, up-to-dateness, and suitability with the research questions (RQ) that had been set. These articles are then used as the main source in the implementation of this *Systematic Literature Review* (SLR).

Table 1: *Journal Grouping*

Yes	Journal	Sum
1	Proceedings of the National Seminar on Biology VI	1
2	Journal of Mathematics and Mathematics Education (MATHLINE)	1
3	Journal of Mathematics Education PRINCIPLES	1
4	Journal of Mathematics Education	1
5	HOTS Research Journal of Mathematics Education (KOGNITIF)	1
6	Journal of Mathematics Education (JUPITEK)	1

7	Scientific Journal of Basic Education (PENDAS)	1
8	Journal of Mathematics Education (REFLESIA)	1
9	Proceedings of the National Seminar on Biology of FMIPA UNM	1
10	Competencies of the University of Balikpapan	1
11	Archipelago of Research	1
12	Didaktik Imliah Journal	1
13	Journal of Biology Education (JPB)	1
14	Journal of Mathematics Education (AlphaMath)	1
15	Journal of Education: Journal of Research Results and Literature Review in the Field of Education, Teaching and Learning	1
16	Journal of Education and Learning (EDUKASIA)	1
17	Journal of Mathematics and Mathematics Education (IMAJINER)	1
18	Journal of Biology Education (BIOEDOUKASI)	1
19	Cogent Education	1
20	International Conference on Mathematics, Science and Education	1

Table 2: *Quality Assessment Results*

Yes	Literature	Year	Q1	Q2	Q3	Result
1	The Relationship of Metacognition Skills with Improved Learning Outcomes (Tenri & Rivai, 2020)	2020	✖	✓	✓	✓
2	The Effect of Metacognition Ability on Mathematics Learning Outcomes of High School Students (Nirfayanti & S, 2021)	2021	✓	✓	✓	✓
3	Metacognition in Mathematics Learning (Pure, 2019)	2019	✓	✓	✓	✓

4	Metacognition Strategies to Improve Students' Mathematics Learning Outcomes (Scott, 2014)	2014	✓	✓	✓	✓
5	The Effect of Metacognition Ability on Students' Mathematical Learning Outcomes (Syamsuriyawati et al., 2024)	2024	✓	✓	✓	✓
6	The Influence of Cognitive Skills on Online Mathematics Learning Outcomes (Wahyuddin et al., 2022)	2022	✓	✓	✓	✓
7	Metacognition Approach as an Alternative to Mathematics Learning (Annie, 2021)	2021	✓	×	✓	✓
8	Implementation of the Make a Match Learning Model to Improve Students' Metacognition in Mathematics Learning (Taufik, 2022)	2022	✓	×	✓	✓
9	The Relationship between Metacognitive Knowledge, Critical Thinking Skills, and Science Literacy Skills with Cognitive Learning Outcomes of State High School Students in Makassar City (Syawal & Bahri, 2023)	2023	✓	✓	✓	✓
10	The Effect of Metacognition and Student Learning Activity on Mathematics Learning Outcomes (Ulichusna et al., 2019)	2019	✓	✓	✓	✓
11	The Effect of Metacognition Ability on Mathematics Learning Outcomes	2015	✓	✓	✓	✓

	at SMP Negeri 2 Leuwimunding, Majalengka Regency (Nurmalasari et al., 2015)					
12	The Relationship of Metacognition and Self Efficacy to the Learning Outcomes of Mathematics Education Students at Ikip Gunungsitoli (Zega, 2021)	2021	✓	✓	✓	✓
13	The Relationship between Students' Metakogen Awareness and Science Learning Outcomes through the Application of Problem-Based Learning Model at SMP Negeri 2 Kuripan (Anindya et al., 2019)	2019	✗	✓	✓	✓
14	The Relationship between Learning Independence, Students' Attitude towards Mathematics Learning and Metacognition Ability with Mathematics Learning Outcomes of Class X Students Even Semester of SMK Muhammadiyah Prambanan Sleman Regency Academic Year 2015/2016 (Susanto & Khasanah, 2017)	2017	✓	✓	✓	✓
15	Analysis of the Relationship between Metacognitive Awareness and Mathematics and Science Learning Outcomes of High School Students in Mataram City (Fitria et al., 2020)	2020	✓	✓	✓	✓

16	The Relationship of Metacognition Ability to Biology Learning Achievement of Grade XI Students of At-Taqwa Modern Islamic Boarding School Gunung Putri Bogor (Emilda et al., 2020)	2020	✓	✓	✓	✓
17	Analysis of Vocational Students' Metacognition Ability in Problem Solving Reviewed from Reflective-Impulsive Cognitive Style and Learning Outcomes (Muryanti et al., 2020)	2020	✗	✓	✓	✓
18	The Relationship between Metacognitive Ability and Learning Motivation with Biology Learning Outcomes Class IX MTs N Metro Academic Year 2013/2014 (Scott, 2014)	2014	✗	✓	✓	✓
19	A meta-analysis of the effect of metacognitive instruction on mathematics achievement (Hidayat et al., 2025)	2025	✓	✓	✓	✓
20	Analysis of mathematical problem-solving ability based on metacognition on problem-based learning (Mulyono & Hadiyanti, 2018)	2018	✓	✓	✓	✓

Symbol Description:

✓ : For Data or library materials used in research.

✗ : For Data or library materials that are not used in the research

1. **RQ1. What is the relationship between metacognition skills and student learning outcomes in mathematics learning?**

Table 3: *The Relationship of Metacognition Ability with Learning Outcomes*

Yes	Research	Key Findings	Types of Relationships
1	(Tenri & Rivai, 2020)	There is a positive and significant relationship between metacognition abilities and learning outcomes	Positive
2	(Nirfayanti & S, 2021)	Metacognition ability has a significant effect on students' mathematics learning outcomes	Positive
3	(Pure, 2019)	Metacognition skills have an important role in solving mathematical problems	Positive
4	(Scott, 2014)	The learning process and student learning outcomes show a better state with the application of metacognition	Positive
5	(Syamsuriyawati et al., 2024)	The ability of metacognition has a significant effect on students' mathematical learning outcomes.	Positive
6	(Wahyuddin et al., 2022)	Metacognition and intelligence have a positive and significant effect on online mathematics learning outcomes	Positive
7	(Annie, 2021)	Based on the results of the analysis of students' responses to metacognition learning, it shows that students have a positive attitude towards mathematics learning with a metacognition approach	Positive
8	(Taufik, 2022)	Learning that uses a make a match learning model based on metacognition has a very	Positive

		strong influence on meta on the learning outcomes of didk participants	
9	(Syawal & Bahri, 2023)	There is a significant positive relationship between metacognitive knowledge, critical thinking skills, and science literacy skills and student learning outcomes	Positive
10	(Ulichusna et al., 2019)	There is a joint influence between metacognition and student learning activity on the mathematics learning outcomes of grade VIII students of SMP Negeri 6 Balikpapan for the 2018/2019 Academic Year	Positive
11	(Nurmalasari et al., 2015)	There is an influence between metacognition abilities on mathematics learning outcomes	Positive
12	(Zega, 2021)	There is a link between metacognitive and self-efficacy students to mathematics learning outcomes.	Positive
13	(Anindya et al., 2019)	The results showed that there was an increase in metacognition awareness with an average of 0.11 for class VIII A and 0.23 for class VIII E and there was a positive and significant relationship between students' metacognition awareness and science learning outcomes	Positive
14	(Susanto & Khasanah, 2017)	The results showed that there was a positive and significant relationship between self-directed learning, students' attitudes towards mathematics learning and metacognition abilities and mathematics learning outcomes	Positive
15	(Fitria et al., 2020)	There is a correlation between metacognitive awareness and the learning outcomes of	Positive

		mathematics and science high school students in the city of Mataram.	
16	(Emilda et al., 2020)	There is a positive relationship between metacognition abilities and students' biology learning achievement	Positive
17	(Muryanti et al., 2020)	The metacognition ability of vocational school students is seen from students with a reflective cognitive style and students with an impulsive cognitive style with learning outcomes	Positive
18	(Scott, 2014)	There is a positive relationship between metacognitive abilities and students' biology learning outcomes	Positive
19	(Hidayat et al., 2025)	Exploring the phenomenon of metacognition abilities can result in significant improvements in mathematical performance.	Positive
20	(Mulyono & Hadiyanti, 2018)	Students are able to solve problems through learning that indicates metacognition abilities with good learning outcomes	Positive

Based on the results of the analysis of 20 articles reviewed, it was found that there was a positive and significant relationship between metacognition skills and mathematics learning outcomes. Students who have good metacognitive abilities tend to be able to manage their own way of learning, plan the right strategies, monitor their thinking process, and evaluate the steps that have been taken.

Metacognitive abilities help students to be more aware of their thought processes so that they are able to correct mistakes and find more effective ways of learning. Improving this ability has a direct impact on improving learning outcomes. In general, students with high metacognitive awareness have a better understanding of concepts and are able to apply high-level thinking strategies in solving mathematical problems.

Thus, the results of the analysis show that the higher the student's metacognition ability, the better the learning outcomes achieved. This proves that metacognitive abilities play an important role in helping students achieve optimal mathematics learning outcomes.

2. **RQ2. What is the tendency of research results that discuss the relationship between metacognition abilities and student learning outcomes?**

Table 4: *Trends in Discussion of Previous Research Results*

Yes	Year	Research Trends	Relationship
1	2015-2019	The research is still correlational, but it shows a positive relationship.	Positive
2	2020-2022	Increasing experimental and quasi-experimental research on metacognition-based learning.	Positive
3	2023-2025	There has been a literature review and meta-analysis that strengthens the evidence of the relationship between metacognition and learning outcomes.	Positive

The results of the study show that previous research has a positive and consistent tendency in highlighting the relationship between metacognition abilities and mathematics learning outcomes. The application of metacognition-based learning has been proven to improve students' understanding of concepts, critical thinking skills, and problem-solving skills. This confirms that learning approaches that foster metacognitive awareness are able to significantly improve mathematics learning outcomes.

3. **RQ3. What are the types of research used in previous studies to examine the relationship between metacognition abilities and student learning outcomes in mathematics learning?**

Table 5: *Types of Research Used*

Yes	Research	Types of Research
1	(Tenri & Rivai, 2020)	Literature review
2	(Nirfayanti & S, 2021)	Ex-post facto
3	(Pure, 2019)	Descriptive qualitative

4	(Scott, 2014)	Experiment
5	(Syamsuriyawati et al., 2024)	Ex-post facto
6	(Wahyuddin et al., 2022)	Quantitative
7	(Annie, 2021)	Quasi-Experimental
8	(Taufik, 2022)	Quantitative
9	(Syawal & Bahri, 2023)	Ex-post facto
10	(Ulichusna et al., 2019)	Quantitative associative
11	(Nurmalasari et al., 2015)	Ex-post facto
12	(Zega, 2021)	Ex-post facto
13	(Anindya et al., 2019)	Qualitative correlational descriptive
14	(Susanto & Khasanah, 2017)	Quantitative
15	(Fitria et al., 2020)	Correlation
16	(Emilda et al., 2020)	Quantitative
17	(Muryanti et al., 2020)	Descriptive qualitative
18	(Scott, 2014)	Quantitative
19	(Hidayat et al., 2025)	Meta-analysis
20	(Mulyono & Hadiyanti, 2018)	

Based on the results of the analysis, previous studies used various methods, with quantitative approaches being the most dominant, especially correlation and experimental methods. A small number of studies use descriptive qualitative approaches and literature reviews, while Systematic Literature Review (SLR)-based research is still limited. This shows that this SLR research is important to provide a systematic picture of the relationship between metacognition abilities and learning outcomes in mathematics learning.

Discussion

Table 6: *Synthesis Results of SLR Studies*

RQ Code	Study Focus	Key Findings	Novelty	Final Synthesis

RQ1	The relationship between metacognition abilities and mathematical learning outcomes	All articles show a positive and significant relationship between metacognition abilities and math learning outcomes. Students who are able to control, monitor, and reflect on their thinking process show better learning outcomes.	Recent research confirms that metacognitive abilities not only affect learning outcomes, but also on high-level thinking skills and active learning.	It can be concluded that the higher the students' metacognition ability, the higher the mathematics learning outcomes achieved. Metacognition is an important factor that determines the success of learning.
RQ2	Trends in previous research results on the relationship between metacognition abilities and learning outcomes	In the period 2015–2025, the trend of research shows consistently positive results. Initially it focused on basic relationships, then progressed to the application of metacognition-based learning and self-reflection.	The novelty can be seen in the emergence of reflective learning approaches and self-regulated learning that integrate metacognition aspects more deeply	The direction of the research is evolving from simple relationship testing to learning implementations that foster metacognitive awareness directly to improve mathematics learning outcomes.
RQ3	The research method used in researching the relationship between metacognition	Most studies use quantitative methods (correlational and experimental). A small number use descriptive qualitative	The novelty of this research lies in the use of the Systematic Literature Review (SLR) approach which has not been	The synthesis shows the need for more SLR-based research or meta-analysis in order to obtain a comprehensive

	ability and learning outcomes	and literature reviews. SLR research and meta-analysis are still very limited.	widely used in this topic.	picture of the pattern of the relationship between metacognition and mathematics learning outcomes.

Based on the results of the analysis of twenty research articles, it was obtained that metacognition ability has a strong relationship with mathematics learning outcomes. Almost all studies show a positive and significant influence between the two. Students who have high metacognitive abilities are able to organize, monitor, and evaluate their thought processes during learning, so that they can understand concepts and solve problems more effectively. These findings reinforce the view that metacognition abilities play an important role in determining the success of learning mathematics.

In terms of study development, previous research has shown a consistent tendency to place metacognition as an important factor in achieving learning outcomes. Initially, the research focused more on the basic relationship between the two variables. However, in recent years, the focus of research has begun to shift towards the application of metacognition-based learning that emphasizes mindfulness, self-reflection, and the regulation of learning strategies. This development shows a shift from traditional approaches to more reflective and independent learning.

From a methodological aspect, most previous studies used a quantitative approach with correlational and experimental methods to identify the influence of metacognition on learning outcomes. A small percentage use a qualitative approach to describe the metacognitive thinking process of students in depth. However, research based on Systematic Literature Review (SLR) is still very limited. Therefore, this study has novelty in providing a systematic synthesis of various previous research results, so that it can be the basis for the development of a more effective mathematics learning model oriented towards strengthening metacognition skills.

4) CONCLUSIONS

The results of this literature review show that students who have good metacognition skills tend to get better mathematics learning outcomes, considering that they can plan, monitor, and evaluate

their thinking processes more effectively. Previous research trends have shown consistent patterns that learning that fosters metacognitive awareness results in improved learning outcomes, and the most commonly used methods are quantitative with correlational and experimental approaches. Since the systematic literature review approach is still limited, this study offers a comprehensive and systematic picture that can be the basis for the development of mathematics learning that is more responsive to strengthening students' metacognition skills.

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