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META-SYNTHESIS OF METACOGNITION'S ROLE IN ENHANCING MATHEMATICAL CRITICAL THINKING

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a b s t r a c t

This study aims to analyze and synthesize various research findings on the role of metacognition in developing students' mathematical critical thinking skills. The method employed is a qualitative meta-synthesis using a systematic literature review approach on six published articles from 2020 to 2025 that are relevant to metacognition and critical thinking in mathematics learning. The analysis was conducted through thematic coding and cross-study interpretation to identify patterns, distinctions, and theoretical development directions. The synthesis results indicate that metacognition functions as a regulatory mechanism of intellectual awareness, guiding students to plan, monitor, and evaluate their thinking processes reflectively. The relationship between metacognition and critical thinking is reciprocal and hierarchical: metacognition serves as the foundation for critical thinking, while critical thinking reinforces metacognitive awareness through continuous reflection. These findings highlight a paradigm shift from *metacognition as a teaching strategy* to *metacognition as a cognitive architecture*. This study recommends the development of a conceptual model of the *metacognitive–critical thinking cycle* within mathematics learning contexts that are adaptive to students' cognitive and cultural characteristics.

Keywords:
Metacognition; Mathematical Critical Thinking; Meta-Synthesis

INTRODUCTION

Mathematical critical thinking skills are one of the core competencies of the 21st century that form the foundation for students in problem solving, rational decision making, and adapting to the challenges of a dynamic world (Arini et al., 2022; Fitaloka et al., 2022). In the context of mathematics learning, critical thinking requires not only mastery of procedures, but also the ability to analyze, evaluate, conclude, and verify solutions logically and systematically (Faiziyah & Priyambodho, 2022a; Hetty Marhaeny & Faza Fariha, 2024). However, various empirical studies show that this ability is still low among Indonesian students, as reflected in the PISA and TIMSS results, which place Indonesia at the bottom in mathematics literacy and higher-order reasoning (Arini et al., 2022; Habib Ramadhani et al., 2020).

One key factor believed to encourage the development of mathematical critical thinking is metacognition, the ability of individuals to be aware of, plan, monitor, and evaluate their own thinking processes (Fitaloka et al., 2022; Liani et al., 2025). Metacognition enables students not only to solve problems, but also to understand how they solved them, why certain strategies were chosen, and whether the resulting solutions are valid (Faiziyah & Priyambodho, 2022a). In learning practice, metacognition-based approaches have been integrated through various models, such as Problem-Based Learning (PBL) (Fitaloka et al., 2022; Habib Ramadhani et al., 2020), explicit metacognitive strategies (Arini et al., 2022; Liani et al., 2025), and ethnomathematics-based contextual approaches (Hetty Marhaeny & Faza Fariha, 2024). Consistent findings from these studies show that metacognitive interventions significantly improve mathematical critical thinking skills compared to conventional learning.

However, the role of metacognition in the development of mathematical critical thinking has not been holistically understood. Some studies treat it as a learning strategy, while others view it as an individual cognitive characteristic that underlies critical thinking skills (Faiziyah & Priyambodho, 2022a; Liani et al., 2025). These differing perspectives raise the question: how exactly does metacognition contribute to the development of mathematical critical thinking? In addition, the context of its application also varies, ranging from junior high school (Arini et al., 2022; Habib Ramadhani et al., 2020), high school (Fitaloka et al., 2022; Liani et al., 2025), to teacher education (Hetty Marhaeny & Faza Fariha, 2024), thus requiring a systematic synthesis to identify general patterns and specific contexts that moderate this relationship.

Therefore, this study aims to conduct a qualitative Systematic Literature Review (SLR) to answer the question: What is the role of metacognition in the development of mathematical critical thinking skills? By analyzing six empirical studies that are rigorous in focus and methodology, this SLR contributes to the theoretical understanding of the cognitive mechanisms behind mathematical critical thinking, while also providing practical recommendations for educators in designing learning that fosters.

METHODS

This study employs a Systematic Literature Review (SLR) approach following the PRISMA protocol to transparently identify, evaluate, and synthesize relevant empirical evidence. (Elmawati & Juandi, 2022)

RESEARCH QUESTIONS (RQ)

This SLR is designed to answer the following four research questions:

1. RQ1: How is metacognition applied in studies of mathematical critical thinking skills?
2. RQ2: What empirical evidence shows the relationship between metacognition and mathematical critical thinking skills?
3. RQ3: What contextual factors (educational level, learning approach, measurement instruments) moderate this relationship?
4. RQ4: What research gaps have not been explored in the current literature?

STRATEGI PENCARIAN DAN SELEKSI STUDI

The search and selection process was conducted iteratively and using multiple sources to ensure adequate coverage while maintaining a strict focus. The steps are as follows:

1. Initial Search (Watase):
   The initial search was conducted through the Watase platform using the keywords "metacogniti" AND "critical thinking"' in the Scopus database, covering the period 2020–2025. This process yielded 137 articles. After screening based on abstract completeness, title/abstract relevance, and full-text accessibility, 14 articles remained for the eligibility stage. However, only 1 article actually met the inclusion criteria because of its focus on mathematical critical thinking.
2. Expanded Search (Other Sources):
   Given the very limited number of articles that met the criteria, the researchers expanded their search through Publish or Perish (PoP) and Google Scholar using a manual search strategy based on topic relevance. This search yielded 10 additional potential articles.
3. Final Selection:
   A total of 11 articles (1 from Watase + 10 from other sources) were then reviewed in depth. Only articles that explicitly examined mathematical critical thinking (not general critical thinking, science, or physics) and involved metacognition as the main variable were retained. This process resulted in 6 final articles that were used in the synthesis.

PRISM DIAGRAM SELECTION FLOW

Stage	Number of Articles	Description
IDENTIFICATION		
Initial search via Watase (Scopus, 2020–2025)	137	Keywords: "metacognitive" and "critical thinking"
Additional search via Publish or Perish & Google Scholar	+10	Manual search based on relevance
Total Identified	147	
SCREENING		
Duplicates removed	–0	
Outside year range / no abstract / irrelevant	–84	
Title/abstract does not focus on mathematical critical thinking	–49	
Articles Enter Eligibility Stage	14	
ELIGIBILITY		
Full-text not available	–3	

Focus on science/physics/general critical thinking (not mathematical)	–5	
INCLUDED	6	All focus on metacognition and mathematical critical thinking

INCLUSION AND EXCLUSION CRITERIA

a. Inclusion:
    1. Empirical studies (quantitative, qualitative, or mixed);
    2. Focus on mathematical critical thinking skills;
    3. Involving metacognition as a predictor, intervention, or key variable;
    4. Published between 2020–2025;
    5. Available in Indonesian or English.
b. Exclusion:
    1. Theoretical studies, editorials, or policy reports;
    2. Focus on critical thinking in science, physics, language, or general fields;
    3. Did not measure or analyze the relationship with metacognition.

DATA EXTRACTION AND ANALYSIS

Data from the 6 included articles were extracted into a synthesis table covering:

1. Author and year
2. Context (grade level, mathematics subject matter)
3. Research method
4. Measures of metacognition and mathematical critical thinking
5. Key findings related to the relationship

This study applied a narrative thematic synthesis because the heterogeneity of study designs and the small number of eligible studies made a quantitative meta-analysis inappropriate, a situation in line with the recommendations of the SWiM reporting guideline. (Campbell et al., 2020)

Recent studies indicate that the trend in metacognition research within mathematics education is shifting toward integrating cognitive awareness, self-regulated learning, and intellectual reflection (Říčan et al., 2022) This shift underscores the relevance of using a meta-synthesis approach in the present study because it enables a comprehensive interpretation of the interplay between metacognitive processes and reflective, context-based critical thinking.

STUDY QUALITY ASSESSMENT

The quality of the six studies was evaluated based on:

a. Clarity of research design
b. Validity and reliability of instruments
c. Accuracy of data analysis
d. Transparency of findings reporting

All studies used have undergone instrument validity and reliability testing and employ experimental or qualitative designs appropriate to their research objectives and are therefore considered for synthesis.

RESULT AND DISCUSSION

Result

The following is a summary table of data describing the results of the analysis of the six selected articles:

No	Author (Year)	Level	Approach	Metacognition Instrument	Critical Thinking Ability Instrument	Main Findings
1	Habib Ramadhani et al. (2020)	Junior High School	Metacognitive-Based PBL	Observation, Questionnaire	Critical Thinking Test (HOTS)	Metacognitive-based PBL improves critical thinking skills in junior high school students by 0.71 (r)
2	Lilis Arini et al. (2022)	Junior High School	Metacognitive Strategies	Metacognition Questionnaire	Critical Thinking Test (HOTS)	Metacognitive strategies increased critical thinking scores by 20.5% (N-gain)
3	Nuqthy Faiziyah (2022)	Vocational High School	HOTS-Based Experiments	Observation and Interviews	HOTS-Based Student Worksheets	Students with high metacognition demonstrate more complete and structured critical thinking processes
4	Nuryadi et al. (2024)	PGSD	Metacognition-based Ethnomathematics	Questionnaires, Observation	Critical Thinking Questionnaires	Ethnomathematics-based metacognition helps PGSD students understand mathematical concepts in depth

5	Liani et al. (2025)	High School	Cognitive Stage-Based Metacognition	Critical Thinking Test	Critical Thinking Questionnaire	Students in the formal operational stage show a more significant improvement in critical thinking than those in the concrete stage
6	Reza Dea Fitaloka et al. (2022)	High School	PBL with a Metacognitive Approach	Interviews, Observations	Critical Thinking Tests	Metacognitive-based PBL significantly improves critical thinking and mathematical concept understanding ($p<0.001$)

Discussion

4.1 Discussion Based on Research Questions

4.1.1. RQ1: How is metacognition applied in studies of mathematical critical thinking skills?

From the analysis of the six studies, there are several approaches to applying metacognition as a key variable in mathematical critical thinking research:

1. Metacognitive Approach in Learning:
    a. Habib Ramadhani et al. (2020) used a metacognitive-based Problem Based Learning (PBL) approach to develop critical thinking skills in junior high school students. This approach teaches students to plan, monitor, and evaluate the process of solving mathematical problems through structured stages.
    b. Fitaloka et al. (2022) integrated metacognition into PBL with a metacognitive approach, which consists of the following stages: introductory discussion, independent work, data collection, data analysis, synthesis and research generation, and theory validation.
2. Specific Metacognitive Strategies:
    a. Arini et al. (2022) used explicit metacognitive strategies such as self-questioning and self-monitoring to improve critical thinking in junior high school students. These strategies helped students identify the steps needed to solve math problems and monitor their progress in problem solving.
    b. Faiziyah & Priyambodho (2022) developed metacognition-based critical thinking stages consisting of: problem understanding, problem analysis, evaluation, and conclusion drawing. In her research, she found that students with high levels of metacognition were better able to follow these stages completely and in a structured manner.
3. Context-Based Approach:
    a. Hetty Marhaeny & Faza Fariha (2024) implemented an ethnomathematics-based metacognition approach, which links mathematical concepts to local

culture (Keraton Boko Yogyakarta). This approach helps PGSD students understand the connection between mathematics and everyday life.

b. Liani et al. (2025) integrated metacognition with Piaget's stages of cognitive development, noting that high school students in the formal operational stage have different thinking capacities compared to students who are still in the concrete operational stage.

Based on these findings, it can be concluded that metacognition is applied through various approaches that focus on planning, monitoring, and evaluating thinking processes, adjusting to the learning context and students' cognitive development stages.

4.1.2. RQ2: What empirical evidence shows the relationship between metacognition and mathematical critical thinking skills?

The six studies analyzed provide strong evidence of the relationship between metacognition and mathematical critical thinking skills:

1. Improved Critical Thinking:
    a. Habib Ramadhani et al. (2020) found that the application of metacognitive-based PBL improved students' critical thinking skills with a correlation value of $r = 0.71$. This indicates a very strong relationship between metacognition and critical thinking.
    b. Arini et al. (2022) reported a 20.5% increase in N-gain in students' critical thinking scores when given explicit metacognitive strategies.
    c. Fitaloka et al. (2022) produced a $p<0.001$ value in the MANOVA test, indicating a significant increase in critical thinking skills and mathematical concept understanding in the experimental group that used metacognitive-based PBL.
2. Quality of Thinking Process:
    a. Faiziyah & Priyambodho (2022) identified that students with high levels of metacognition demonstrated a more complete and structured critical thinking process. They were able to follow the stages of problem analysis, solution evaluation, and conclusion drawing accurately.
    b. Liani et al. (2025) showed that students who were at the formal operational stage of cognitive development were better able to understand and apply critical thinking concepts than students who were still at the concrete stage.
3. The Role of Metacognition as a Connector:
    a. From the studies analyzed, metacognition functions as a connector between mathematical concept understanding and critical thinking skills. For example, Hetty Marhaeny & Faza Fariha (2024) found that ethnomathematics-based metacognition helped PGSD students understand mathematical concepts in depth, which in turn improved their critical thinking skills.

Based on these findings, it can be concluded that metacognition not only acts as a predictor but also as a key mechanism in the development of mathematical critical thinking. Metacognition enables students to identify weaknesses in their understanding of concepts, monitor problem-solving processes, and reflect on the solutions they have found.

4.1.3. RQ3: What contextual factors moderate this relationship?

Analysis of the studies shows that there are several contextual factors that moderate the relationship between metacognition and mathematical critical thinking skills:

1. Education Level:
   a. Studies involving junior high school students (Arini et al., 2022; Habib Ramadhani et al., 2020) show that PBL-based metacognition is effective in improving critical thinking at the stage of cognitive development that is still in concrete operations.
   b. Studies involving high school students (Fitaloka et al., 2022; Liani et al., 2025) show that cognitive development stage (Piaget) based metacognition is more effective at the formal operations stage.
   c. Studies involving PGSD students (Hetty Marhaeny & Faza Fariha, 2024) show that the ethnomathematics-based metacognition approach is highly relevant in developing conceptual understanding of mathematics.
2. Learning Approach:
   a. The metacognitive-based PBL approach (Fitaloka et al., 2022; Habib Ramadhani et al., 2020) shows better results than the conventional approach.
   b. The HOTS-based metacognition approach (Faiziyah & Priyambodho, 2022a) helps students develop deeper and more critical thinking processes.
   c. The ethnomathematics-based metacognition approach (Hetty Marhaeny & Faza Fariha, 2024) enables students to understand the connection between mathematics and real life, thereby improving conceptual understanding and critical thinking.
3. Measurement Instruments:
   a. Studies using HOTS-based critical thinking tests (Faiziyah & Priyambodho, 2022a; Liani et al., 2025) show better results in measuring critical thinking skills compared to conventional tests.
   b. Studies using validated metacognition questionnaires (Arini et al., 2022) provide more accurate data in measuring students' metacognition levels.
4. Cultural Context
   a. An ethnomathematics-based metacognition approach (Hetty Marhaeny & Faza Fariha, 2024) shows that the local cultural context can be a source of inspiration in developing conceptual understanding of mathematics and critical thinking.

Based on these findings, it can be concluded that educational context, learning approach, measurement instruments, and cultural context act as moderators in the relationship between metacognition and mathematical critical thinking. Therefore, approaches that are relevant to the context and developmental stage of students will result in optimal improvement in critical thinking.

4.1.4. RQ4: What research gaps have not been explored in the current literature?

Based on the analysis of the six studies, there are several research gaps that need to be explored further:

1. Longitudinal Studies:
   Most of the studies analyzed focused on improving critical thinking in the short term. No studies have examined the long-term impact of metacognitive approaches on mathematical critical thinking. Longitudinal research is needed to understand how metacognition shapes critical thinking over time.

2. Development of More Comprehensive Instruments:
   Although some studies used validated instruments (Arini et al., 2022), there is still a need to develop more comprehensive instruments that can measure metacognition and critical thinking in an integrated manner. Specialized instruments can provide a deeper understanding of the relationship between these two variables.
3. Technology-Based Approach:
   There are no studies that combine metacognition with learning technologies, such as adaptive learning systems or AI-powered learning tools. The use of technology in developing metacognition has great potential to improve critical thinking effectively and efficiently.
4. Research at the Elementary School Level:
   Most of the studies analyzed focused on junior high and high school levels. There has been no research examining the relationship between metacognition and mathematical critical thinking at the elementary school level. Due to the different stages of cognitive development at the elementary school age, this research could provide different insights.
5. Integration with the Curriculum:
   No studies explicitly discuss how metacognition can be systematically integrated into the mathematics curriculum. Research is needed to identify concrete steps for integrating metacognition into everyday mathematics learning.
6. Research with a More In-Depth Qualitative Approach:
   Although qualitative research such as that conducted by Hetty Marhaeny & Faza Fariha (2024) and Faiziyah & Priyambodho (2022) is very valuable, more in-depth research with a qualitative approach is still needed to understand the psychological mechanisms underlying the relationship between metacognition and critical thinking.

4.2. Critical Discussion

The synthesis of six studies shows that metacognition plays a central role in shaping mathematical critical thinking skills, but its manifestation and depth of understanding vary across research contexts. In general, all studies agree that awareness of thinking processes is a prerequisite for logical decision making and reflective mathematical problem solving. However, this meta-synthesis reveals that most studies still place metacognition as an instrumental learning strategy, rather than as a structural cognitive mechanism in critical thinking. This difference in perspective determines the extent to which the effectiveness of metacognitive interventions can be sustained in the long term.

From an epistemological perspective, the research conducted by Habib Ramadhani et al. (2020) and Fitaloka et al. (2022) represents the metacognition-as-intervention paradigm, in which thinking awareness is trained through reflection-based PBL stages. Such studies show a strong positive relationship between metacognitive training and improved critical thinking skills, but their conceptual depth is limited to the domain of learning behavior. In contrast, the research by Faiziyah & Priyambodho (2022) and Hetty Marhaeny & Faza Fariha (2024) views metacognition as an internal construct integrated with conceptual understanding. This approach emphasizes that critical thinking is not merely the result of pedagogical intervention, but rather a reflection of epistemic self-awareness of mathematical knowledge. Thus, this meta-synthesis reveals a paradigm shift from metacognition as a teaching strategy to metacognition as a cognitive architecture.

From a methodological perspective, all studies demonstrate a commitment to relevant empirical designs, but most are still quasi-experimental in nature with short intervention durations. This implies that the evidence obtained is more situational than longitudinal. In the context of meta-synthesis, this becomes an epistemic limitation: critical thinking skills may increase temporarily due to the treatment effect, rather than due to stable changes in cognitive structure. Therefore, future research needs to extend the observation period to assess how metacognition shapes reflective thinking habits.

Cross-level analysis shows that the educational context is an important moderator in the success of critical thinking development. The application of metacognition in junior high and high school students (Habib Ramadhani et al., 2020; Liani et al., 2025) is still exploratory and dependent on teacher guidance, while in PGSD students (Hetty Marhaeny & Faza Fariha, 2024)) it has begun to show internalization of thinking awareness as an independent reflective practice. This pattern indicates a continuum of metacognitive development, where pedagogical interventions need to be adjusted to the cognitive stage of learners as theorized by Piaget. It is at this point that the integration of Flavell's theory of awareness and regulation of thinking becomes relevant, as it shows that critical thinking is only possible when students can assess and control their own thinking strategies.

Metacognition not only functions as an individual's awareness of their thinking processes but also plays a direct role in improving mathematical achievement. A meta-analysis study by Muncer et al. (2022) shows that there is a significant positive correlation between metacognitive abilities and mathematical performance in adolescents. This correlation reinforces Flavell's view that planning, monitoring, and evaluating thinking strategies are key for students to effectively control their cognitive processes. In addition, Güner & Erbay (2021) found that students with high metacognitive skills are better able to solve complex problems because they can recognize logical errors in their thinking processes.

From a conceptual perspective, this meta-synthesis confirms that the relationship between metacognition and critical thinking is reciprocal and hierarchical. Metacognition is not only a prerequisite for critical thinking but is also strengthened through repeated critical thinking practices. This relational model challenges the previous linear view that considers metacognition as a single independent variable. These integrated findings are consistent with the framework of Ennis and Facione, which places self-regulation and self-evaluation at the core of critical thinking, while also supporting Flavell's assumption that cognitive awareness is the highest control mechanism in information processing.

The findings of this meta-synthesis align with international research trends that highlight metacognition as a cognitive architecture supporting the development of critical thinking skills across knowledge domains. In mathematics education, this perspective reinforces the view that metacognitive awareness functions not only as a learning facilitator but also as a system that enables learners to maintain continuous intellectual control over problem-solving and decision-making processes (Syaiful et al., 2022).

In line with this theory, recent research confirms that mathematical critical thinking skills are not only developed through formal logic exercises, but also through reflective awareness of the thinking process itself. A study by Hunaifi & Juandi (2023) shows that the application of metacognitive strategies in mathematical problem solving can improve students' inference and argument evaluation skills. Furthermore, research by de Almeida & de Castro (2023) emphasizes the importance of instruments that identify metacognitive strategies in mathematical modeling activities, as this aspect determines the extent to which students are able to think critically about the mathematical results and processes, they carry out.

In addition, there are also indications that cultural dimensions play a significant role in interpreting and fostering metacognitive awareness. The ethnomathematics approach (Hetty Marhaeny & Faza Fariha, 2024) shows that cognitive reflection cannot be separated from the context of local values and meanings. Mathematical critical thinking awareness in Indonesian classrooms appears to be more developed when learning is rooted in the cultural experiences of students. This opens up a new direction that the development of metacognition needs to be viewed as a socio-cognitive practice, not merely an individual-cognitive one.

Overall, this critical analysis shows that although empirical findings have consistently supported a positive relationship between metacognition and mathematical critical thinking, the quality of this relationship is highly dependent on how the research defines metacognition itself. This meta-synthesis recommends a theoretical reinterpretation that metacognition should be understood as a system of intellectual awareness regulation that frames the entire critical thinking process, not just as a learning strategy. This perspective opens up space for the development of a new conceptual model of the metacognitive-critical thinking cycle that integrates awareness, regulation, and reflection as a unified mathematical thinking process.

4.3. Practical Implications

Based on the findings, several practical implications can be given to educators:

i. Integration of Metacognition in Lesson Plans:
Teachers should incorporate metacognitive activities into mathematics lesson plans, such as asking reflective questions, teaching self-questioning strategies, and encouraging students to reflect on the problem-solving process.

ii. Development of More Comprehensive Instruments:
It is necessary to develop instruments that can measure metacognition and critical thinking in an integrated manner. These instruments can be used to assess student development on an ongoing basis.

3. Teacher Training on Metacognition:
Special training is needed for teachers on the concept of metacognition and strategies for its development. Teachers who understand metacognition will be better able to guide students in developing critical thinking skills.

4. Application of Approaches Appropriate to Cognitive Developmental Stages:
Teachers must understand students' cognitive developmental stages and use appropriate approaches. For example, for students in the concrete operational stage, more concrete and visual approaches will be more effective.

5. Use of Local Cultural Contexts:
In the Indonesian context, the use of ethnomathematics or local cultural contexts can be an effective means of developing students' conceptual understanding of mathematics and critical thinking.

5.1. Research Limitations

This study has several limitations that need to be considered:

1. Limited Number of Studies:
The analysis was only conducted on 6 selected articles, which may not fully reflect the diversity of approaches in the development of metacognition and mathematical critical thinking.

2. Limitations in Existing Studies:
Most of the studies analyzed had quasi-experimental designs, so the causal relationship between metacognition and critical thinking needs to be strengthened through further research.

iii. Bias in the Indonesian Context:
Most of the studies analyzed were from the Indonesian context, so the results of the study may not be generalizable to other contexts.

i. Limitations of Qualitative Studies:
The qualitative studies analyzed (Faiziyah & Priyambodho, 2022b; Hetty Marhaeny & Faza Fariha, 2024) provide valuable insights but lack quantitative data to reinforce the findings.

CONCLUSION

From the analysis of the six selected studies, it can be concluded that metacognition plays an important role in the development of mathematical critical thinking skills. Metacognition enables students to identify problem-solving steps, monitor thinking processes, and reflect on the solutions found. The results of this study show that approaches that integrate metacognition into mathematics learning, such as metacognitive-based PBL, explicit metacognitive strategies, and ethnomathematics-based approaches, significantly improve students' critical thinking skills.

These findings have important implications for mathematics education, particularly in efforts to improve the quality of learning and prepare students for the challenges of the 21st century. Therefore, it is hoped that educators and policymakers will consider integrating metacognition into mathematics curricula and learning practices.

REFERENCES

Arini, L., Duskri, M., & Yani, M. (2022). Penerapan Strategi Metakognitif Terhadap Kemampuan Berpikir Kritis Matematis Siswa. *Pedagogik: Jurnal Ilmiah Pendidikan Dan Pembelajaran*, *9*(1), 111–120.

Campbell, M., McKenzie, J. E., Sowden, A., Katikireddi, S. V., Brennan, S. E., Ellis, S., Hartmann-Boyce, J., Ryan, R., Shepperd, S., Thomas, J., Welch, V., & Thomson, H. (2020). Synthesis without meta-analysis (SWiM) in systematic reviews: Reporting guideline. *The BMJ*, *368*, 1–6. https://doi.org/10.1136/bmj.l6890

de Almeida, L. M. W., & de Castro, É. M. V. (2023). Metacognitive Strategies in Mathematical Modelling Activities: Structuring an Identification Instrument. *Redimat*, *12*(3), 210–228. https://doi.org/10.17583/redimat.12926

Elmawati, E., & Juandi, D. (2022). Mathematical Critical Thinking Ability In Indonesia: Systematic Literature Review (SLR). *Symmetry: Pasundan Journal of Research in Mathematics Learning and Education*, *7*(2), 210–221. https://doi.org/10.23969/symmetry.v7i2.6426

Faiziyah, N., & Priyambodho, B. L. (2022a). Analisis Kemampuan Berpikir Kritis Dalam Menyelesaikan Soal Hots Ditinjau Dari Metakognisi Siswa. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *11*(4), 2823. https://doi.org/10.24127/ajpm.v11i4.5918

Faiziyah, N., & Priyambodho, B. L. (2022b). Analisis Kemampuan Berpikir Kritis Dalam Menyelesaikan Soal Hots Ditinjau Dari Metakognisi Siswa. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *11*(4), 2823. https://doi.org/10.24127/ajpm.v11i4.5918

Fitaloka, R. D., Netriwati, N., & Fadila, A. (2022). Pengaruh Model Pembelajaran Problem Based Learning Dengan Pendekatan Metakognitif Terhadap Kemampuan Berpikir Kritis Dan Pemahaman Konsep Matematis. *Hipotenusa Journal of Research Mathematics Education (HJRME)*, *5*(2), 74–89. https://doi.org/10.36269/hjrme.v5i2.847

Güner, P., & Erbay, H. N. (2021). Metacognitive Skills and Problem-Solving. *International Journal of Research in Education and Science*, *7*(3), 715–734. https://doi.org/10.46328/ijres.1594

Habib Ramadhani, M., Yayah Haenilah, E., Lampung, U., & Ir Sumantri Brojonegoro, J. (2020). *Efektivitas Model Problem Based Learning Bersasis Metakognitif Terhadap Kemampuan Berpikir Kritis Matematis*. *04*(02), 1064–1071.

Hetty Marhaeny, N., & Faza Fariha, N. (2024). Persepsi Kemampuan Berpikir Kritis Melalui Pendekatan Metakognisi Berbasis ETNOMATEMATIKA. In *Jurnal Rinjani Pendidikan Guru Sekolah Dasar* (Vol. 2, Issue 01). https://jurnalrinjanipendidikan.com/index.php/JR-PGSD

Hunaifi, H., & Juandi, D. (2023). The effect of metacognitive strategies on mathematical problem-solving ability: A systematic literature review. *AIP Conference Proceedings*, *2734*(1). https://doi.org/10.1063/5.0175086

Liani, A. M., Hamid, A., & Abidin, M. R. (2025). Eksplorasi Strategi Metakognitif Untuk Meningkatkan Kemampuan Berpikir Kritis Matematika Siswa. *Jupika: Jurnal Pendidikan Matematika*, *8*(1), 91–100. https://doi.org/10.37478/jupika.v8i1.5404

Muncer, G., Higham, P. A., Gosling, C. J., Cortese, S., Wood-Downie, H., & Hadwin, J. A. (2022). A Meta-Analysis Investigating the Association Between Metacognition and Math Performance in Adolescence. In *Educational Psychology Review* (Vol. 34, Issue 1). Educational Psychology Review. https://doi.org/10.1007/s10648-021-09620-x

Říčan, J., Chytrý, V., & Medová, J. (2022). Aspects of self-regulated learning and their influence on the mathematics achievement of fifth graders in the context of four different proclaimed curricula. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.963151

Syaiful, Huda, N., Mukminin, A., & Kamid. (2022). Using a metacognitive learning approach to enhance students' critical thinking skills through mathematics education. *SN Social Sciences*, *2*(4), 1–26. https://doi.org/10.1007/s43545-022-00325-8