



The Implementation of Metacognitive Strategies in Elementary Mathematics Learning: A Systematic Literature Review

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Paper received: 14-4-2025; revised: 8-5-2025 ; accepted: 29-9-2025

Abstract

Metacognitive strategies play a critical role in elementary mathematics education by enabling students to plan, monitor, and evaluate their thinking processes. This study conducts a Systematic Literature Review (SLR) to examine the effectiveness of these strategies in enhancing students' conceptual understanding, motivation, and problem-solving abilities. Using the *Publish or Perish* application, 432 articles were initially identified from Scopus, Semantic Scholar, and Google Scholar. Based on established inclusion criteria such as publication type, indexing, language, and relevance, 16 studies were selected for in-depth analysis. The findings reveal that metacognitive strategies significantly improve students' self-regulation, learning independence, and academic performance. However, their effectiveness varies depending on factors such as gender, self-efficacy, classroom environment, and access to technology. The study also highlights the essential role of teachers in modeling cognitive processes, offering feedback, and facilitating reflective learning. Compared to traditional memorization-based instruction, metacognitive approaches foster deeper understanding and cognitive flexibility. This review underscores the need for sustained teacher training and thoughtful technology integration to support effective implementation of metacognitive strategies in primary mathematics learning.

Keywords: metacognitive strategies; mathematics learning; elementary school

INTRODUCTION

Metacognition refers to the conscious awareness and regulation of one's cognitive processes, and it plays a pivotal role in shaping effective learning experiences. Within the context of mathematics education, metacognitive strategies help students plan, monitor, and evaluate their thinking key components in navigating complex problem solving tasks (Rozak et al., 2018). However, research continues to highlight various challenges that hinder students' ability to apply these strategies effectively. Frequent occurrences of blindness, where students fail to recognize errors in their reasoning, and mirage, where learners express misplaced confidence in incorrect strategies, have been documented as common metacognitive failures (Faradiba & Alifiani, 2020). The concept of vandalism, referring to the inappropriate or uncritical application of strategies that do not suit the task demands, has also been identified as a barrier to effective metacognitive engagement (Rozak et al., 2018).

Another form of difficulty, misdirected metacognitive failure, involves students regulating their thinking but focusing on irrelevant or misleading aspects of the task, which ultimately undermines their performance (Stillman, 2011). A more severe breakdown, known as impasse failure, occurs when students acknowledge the presence of a problem but are unable to revise or generate strategies to proceed, resulting in stagnation (Stillman, 2015). These classifications of metacognitive failure highlight the complexity of learning processes in mathematics and the need for explicit instruction to help students become more strategic and reflective in their thinking.

Students' mathematical problem-solving capacities vary significantly across contexts, often influenced by gender, educational setting, and grade level. For example, female students in urban areas tend to outperform their male counterparts in mathematics, a pattern linked to differences in motivation and attitudes toward the subject (Supriadi, 2024). Similarly, students attending public schools generally achieve better problem-solving outcomes than those in private institutions (Johar et al., 2025). Age and developmental stage also matter; older students typically demonstrate more advanced mathematical reasoning than their younger peers (Wong & Yip, 2023). This observation is particularly important when considering that when children engage in problem-solving tasks related to tithing, they employ diverse strategies and attain varying levels of success compared to conventional academic mathematics problems. This suggests that the context in which a mathematical problem is situated can profoundly affect students' capacity to comprehend and resolve it (Taylor & Dobie, 2024).

In addition to demographic influences, many elementary students struggle with understanding key problem elements, particularly the semantic role of unknown variables in story problems. These difficulties often lead to errors in selecting concepts and constructing accurate mathematical expressions, which in turn hinder their problem-solving performance (Wong & Yip, 2023). Empirical findings suggest that student errors are more prevalent during the planning and execution phases than at the initial understanding stage (Amalina & Vidákovich, 2023). Furthermore, limited use of digital learning tools may reduce students' opportunities to build creative and flexible thinking strategies (Chairwut et al., 2025). The integration of technology into learning environments can significantly enhance students' critical and analytical thinking skills (Yasa et al., 2024). By incorporating technology, teachers can take on a more supportive role, helping students develop higher-order thinking skills and improve their problem-solving capabilities.

Students with lower mathematical reasoning abilities tend to face greater challenges in applying their knowledge effectively (Supriadi, 2024). External factors such as socioeconomic status and access to educational resources also contribute to disparities in student performance (Johar et al., 2025). These trends reveal persistent gaps in how students engage with mathematical problem-solving and highlight the need for instructional approaches that support both cognitive and contextual development.

Additionally, the choice of learning media and teaching approaches greatly impacts the success of learning. Innovative, student-centered teaching methods, such as those that incorporate technology, can foster greater student engagement and active participation (Khoirudin et al., 2024). Stress the importance for educators, especially those teaching mathematics, to adopt more creative and effective instructional models. Such approaches can

help make learning more relevant and engaging, ultimately improving student problem-solving abilities (Rahayuningsih et al., 2023).

The objective of this systematic literature review is to synthesize existing research on metacognitive strategies within the context of mathematics education. This review focuses on their efficacy, implementation, and impact on student outcomes. It seeks to answer the following research questions: (1) What is the impact of metacognitive strategies on elementary students' mathematical abilities? (2) What factors influence the implementation of metacognitive strategies in mathematics education? (3) What role do teachers play in implementing these strategies? (4) How do learning approaches that utilize metacognitive strategies differ from those that do not?

Metacognitive strategies involve techniques that help learners plan, monitor, and assess their learning processes. These strategies include self-reflection, systematic planning, and increased awareness of cognitive operations, promoting effective self-directed learning (Siregar et al., 2024). For example, students using metacognition can break down complex problems into manageable parts, simplifying the process (Albalhareth & Alasmari, 2023; Zhang & Lian, 2024). This self-awareness allows them to identify effective methods and adjust their strategies, improving problem-solving outcomes (Schuster et al., 2023). Additionally, metacognitive strategies can reduce anxiety associated with problem-solving tasks. By enhancing learners' control and understanding of their cognitive processes, students gain confidence and perform better (Shen et al., 2024). These benefits make metacognition a critical element in effective mathematics education.

The learning process using metacognitive strategies can be divided into three phases. First, in the planning stage, students set goals and outline steps to solve a problem. They allocate time, anticipate potential obstacles, and prepare resources. Second, during the monitoring phase, they assess their understanding and track the effectiveness of their strategies. This real-time evaluation helps them correct errors and stay engaged. Third, in the evaluation stage, students reflect on their process and outcomes, identifying strengths and areas for improvement. This reflection fosters critical thinking and supports lifelong learning.

However, the successful application of these strategies is not uniform. Contextual factors significantly influence how students engage with mathematics. Classroom practices also play a role. In Thailand, for instance, teacher-centered instruction often limits student engagement, resulting in passive learning and weaker problem-solving skills (Chairwut, 2025). Moreover, students from disadvantaged backgrounds may lack exposure to effective strategies, making it harder to apply metacognitive approaches (Zhang & Lian, 2024). Assessment presents another challenge. Traditional tools may not fully capture the complexity of metacognitive processes, making it difficult to evaluate their impact (Shen et al., 2024). Albalhareth and Alasmari (2023) observed that teachers frequently overlook the evaluation phase, undervaluing the importance of reflection in learning.

METHOD

This research utilizes a systematic literature review (SLR) methodology, conforming to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

framework, to integrate peer-reviewed scholarship concerning metacognitive strategies within primary mathematics education (Haddaway et al., 2022). The SLR protocol ensures methodological rigor through explicitly delineated search strategies, inclusion criteria, and thematic analysis. The process of literature identification occurred in March 2025. The articles were sourced from Scopus, Semantic Scholar, and Google Scholar using the Publish or Perish 8 application. With search string employed was (metacognitive* OR self regulat*) (strategy* OR plan) AND (primary OR elementary) AND (Math* AND learn*) NOT (cognitive), meticulously crafted to encompass studies concentrating on metacognitive methodologies in mathematics education while deliberately excluding cognitive dimensions. Boolean operators (AND/OR) were utilized to amalgamate these terms, and filters were instituted to prioritize studies published between 2015–2025, thereby ensuring relevance to contemporary educational practices. The flowchart presented in **Figure 1** delineates the three-step PRISMA protocol: identification, screening, and inclusion.

Table 1. Search String for Articles Using Publish or Perish 8

| Search String | Database | Number of Article |
|------------------------------------|------------------|-------------------|
| (metacognitive* OR self regulat*) | Scopus | 65 |
| AND (strategy* OR plan) AND | Semantic Scholar | 62 |
| (primary OR elementary) AND | Google Scholar | 305 |
| (Math* AND learn*) NOT (cognitive) | Total | 432 |

Table 1 presents the number of articles retrieved from each database using a search string constructed with Boolean operators. The largest number of articles was found in Google Scholar (305), followed by Scopus (65) and Semantic Scholar (62). Although the initial search yielded a substantial number of results (432 articles in total), many were excluded during the relevance and quality screening stages. The keywords and Boolean operators used in the search were carefully chosen to align with the research objectives, incorporating synonyms to capture a broader range of relevant literature. The collected articles were then assessed further based on the inclusion and exclusion criteria outlined in **Table 2**.

Table 2. Inclusion and Exclusion Criteria

| Inclusion Criteria | Exclusion Criteria |
|---|--|
| Journal articles, conference paper | Articles review, book chapter, thesis and dissertations |
| Articles published between 2015-2025 | Articles published before 2015 |
| Articles indexed in Scopus, Semantic Scholar, and Google Scholar | Articles not indexed in Scopus, Semantic Scholar, and Google Scholar |
| Articles in English or Indonesia | Articles not in English nor Indonesia |
| Full-text access articles | Incomplete access articles |
| Relevant to metacognitive strategies in elementary mathematics learning | Not at the elementary level and did not examine mathematics learning |

Table 2 outlines the inclusion and exclusion criteria applied during article selection. These criteria ensured that only high-quality, relevant, and accessible articles were included in the final analysis. At the initial phase of screening and determining eligibility, a total of 378 academic articles were meticulously selected based solely on their titles, a careful evaluation led

to the determination that 41 of these articles were relevant to the research objectives. Following this initial selection, these articles underwent a more rigorous screening process that involved a comprehensive review of their abstracts and keywords, which ultimately culminated in the identification of 35 articles that satisfactorily met the established criteria for relevance and quality. A detailed and exhaustive review of these 35 articles was then systematically conducted, ultimately resulting in the identification of 16 articles that were conclusively determined to meet the specified criteria for inclusion in the study. Although articles were sourced from Scopus, Semantic Scholar, and Google Scholar, only articles from Scopus and Semantic Scholar fulfilled all the inclusion criteria, such as publication type, relevance to metacognitive strategies in elementary mathematics education, language, and full-text availability. Articles from Google Scholar were excluded as none met all of the required criteria. The article selection process is illustrated in the diagram below.

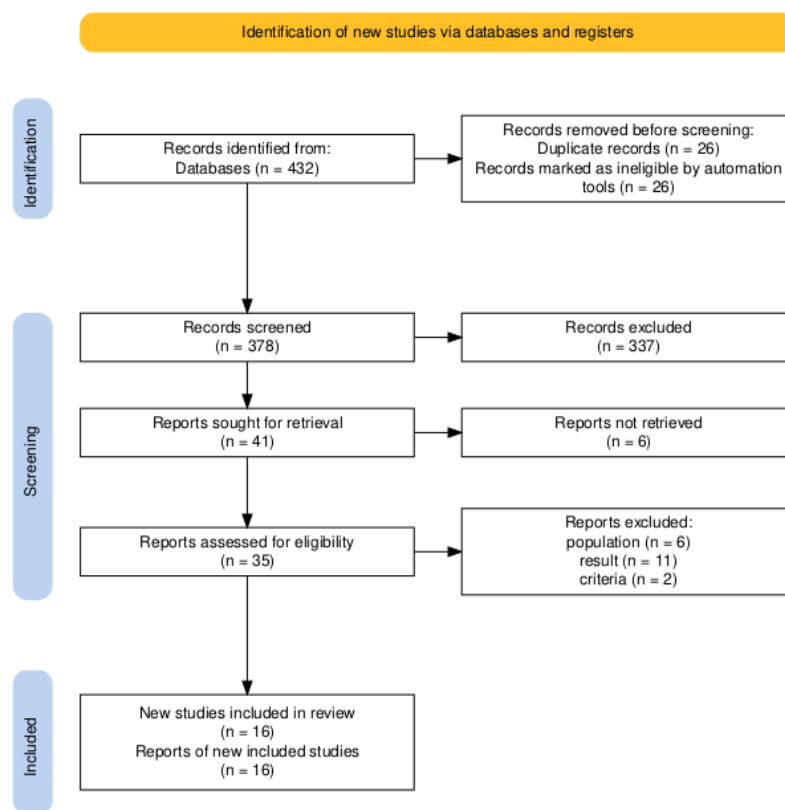


Figure 1. PRISMA Flow Diagram

The data extraction stage is the process of extracting findings from previous studies to obtain valuable data to answer the research questions. Thematic analysis was used in this study as a data analysis technique. Thematic analysis is a qualitative data analysis method that involves identifying, analyzing, and reporting patterns that emerge from the data, resulting in a systematic and comprehensive depiction (Gupta et al., 2024). This technique is applied based on a structured approach to interpreting the meaning of the research.

Table 3. Selected Articles in This Study

| Title | Year | Author | Focus |
|--|------|---|---|
| A metacognitive intervention for teaching fractions to students with or at-risk for learning disabilities in mathematics | 2019 | Sharlene A. Kiuahara and Douglas J. Hacker | To assess the impact of a metacognitive instructional approach based on the SRSD model on improving fraction understanding, mathematical reasoning, and written communication in upper elementary students with math learning disabilities. |
| A self-regulated flipped classroom approach to improving students' learning performance in a mathematics course | 2016 | Chiu-Lin Lai and Gwo-Jen Hwang | To examine the impact of integrating self-regulated learning strategies into a flipped classroom on elementary students' mathematics achievement, time management, and self-efficacy. |
| Academic achievement and self-regulated learning from parent's perspective of student with learning difficulties | 2022 | Ayed Hanna Ziadat and Mohammad Abed Sakarneh | To explore how self-regulated learning and time management affect academic performance in subjects like the Mother Tongue and Mathematics among primary school students. |
| Academic Performance of Excellence: The Impact of Self-Regulated Learning and Academic Time Management Planning | 2024 | Abilio Afonso Lourenço and Maria Olímpia Paiva | To investigate the relationship between self-regulated learning and academic achievement among students with learning difficulties, considering the effects of learning setting, gender, difficulty category, and grade level. |
| Developing Students' Self-regulated Learning Skills with Teacher Classroom Analytics Enhancing Teachers' Direct Instruction of Self-regulated Learning Strategies | 2023 | Melis Dülger | To develop and evaluate a classroom-level teacher dashboard that visualizes students' self-regulated learning (SRL) behaviors in math, aiming to support teachers in monitoring SRL and enhancing their instruction of SRL strategies in primary education. |
| Effects of a self-regulated-based gamified interactive e-books on primary students' learning performance and affection in a flipped mathematics classroom | 2024 | Chuang Chen, Nurullizam Jamiat, Siti Nazleen Abdul Rabu, and Yongchun Mao | To evaluate the effectiveness of a self-regulated-based gamified interactive e-book (S-GIEB) in enhancing sixth-grade students' learning performance, motivation, self-regulation, and meta-cognitive skills in a flipped mathematics classroom. |
| Enhancing Mathematical Metacognition and Self-Efficacy in Third-Graders in Elementary School: Integrating Problem-Posing Activities within the Self-Regulated Learning Cycle | 2024 | Hsi-Hsun Yang and Yen-Hua Chiu | To examine the impact of incorporating problem-posing tasks within a self-regulated learning cycle on third-grade students' mathematical metacognition, self-efficacy, and achievement. |
| Math self-regulated learning assisted by metacognitive support by reviewing sex differences in mathematics anxiety | 2022 | Fenty Rahmawati Fajri and Mohammad Faizal Amir | To analyze the impact of mathematics self-regulated learning (MSRL) supported by metacognitive strategies (MS) on students' mathematics anxiety (MA), with particular attention to sex differences among 3rd-grade primary school students. |

| Title | Year | Author | Focus |
|---|------|--|--|
| Motivational and affective determinants of self-regulatory strategy use in elementary school mathematics | 2015 | Mariza Chatzistamatiou, Irimi Dermizaki, Anastasia Efklides, and Angeliki Leondari | To explore how elementary students' achievement goals in mathematics affect their use of self-regulated learning strategies, and how self-efficacy, value beliefs, and enjoyment mediate this relationship. |
| Multiple Scaffolds Used to Support Self-Regulated Learning in Elementary Mathematics Classrooms: | 2021 | Chiu-Pin Lin and Su-Jian Yang | To examine the impact of a self-regulated learning model supported by scaffolding on elementary students' mathematics performance, comparing it with traditional teaching methods and other digital learning platforms. |
| Problem-Solving Abilities of Mildly Gifted Learners in Grade 3 Mathematics Using Self-Regulated Learning without Direct Teaching | 2023 | Amanda Allers and Prakash Singh | To investigate whether mildly gifted Grade 3 learners can effectively master an enriched advanced-level mathematics curriculum using self-regulated learning strategies, without direct teaching methods. |
| Self-regulated Learning for Elementary School Students' Mathematics Learning Using Think Pair Share | 2024 | Amelia Dwi Astuti | To determine the impact of the Think Pair Share (TPS) learning model on the self-regulated learning (SRL) abilities of fourth-grade elementary students in mathematics. |
| Self-regulated math instructions for pupils with learning disabilities | 2016 | Saied Bishara and Bronwyn Frances Ewing | To compare the effectiveness of self-regulated learning versus traditional teaching methods on the ability of elementary pupils with learning disabilities to solve complex math problems, and to examine whether gender influences these outcomes. |
| The Bifactor Model of the Junior Metacognitive Awareness Inventory (Jr. MAI) | 2019 | Hoi Kwan Ning | To examine the factor structure, validity, and reliability of the Junior Metacognitive Awareness Inventory (Jr. MAI) in assessing metacognition among primary school children in Singapore, and its predictive relationships with learning strategies and mathematics achievement. |
| The impact of metacognitive strategies and self-regulating processes of solving math word problems | 2017 | Eda Vula, Rrezarta Avdyli, Valbina Berisha, and Blerim Saqipi | To investigate the impact of metacognitive strategies and self-regulation processes on elementary students' performance in solving math word problems, with a focus on the linguistic factors and steps involved in the problem-solving process. |
| The role of strategy keys in enhancing heuristics and self-regulation in mathematical problem-solving: A qualitative, explorative, and type-building study with primary school students | 2024 | Raja Herold-Blasius | To explore how primary school students use strategy keys (heuristic aid cards) when solving non-routine mathematical problems and to assess the impact of these tools on their problem-solving processes. |

RESULT AND DISCUSSION

Result

This study collects, selects, and analyzes sixteen relevant articles published during the period between 2015 and 2025 that are relevant to metacognitive strategies in primary school mathematics learning. In this section, we will describe the findings of various studies related to the implementation of metacognitive strategies in primary school mathematics learning. The analysis is organized into five key themes: (1) the impact of metacognitive strategies on students' mathematical abilities, (2) factors influencing the implementation of these strategies, (3) the teacher's role, (4) differences in learning approaches with and without metacognitive strategies, and (5) instructional adaptations based on metacognitive learning.

The Impact of Metacognitive Strategies on Elementary Students' Mathematics Abilities

Metacognitive strategies have consistently been linked to improved mathematical understanding and problem-solving abilities among elementary students. Many learners face difficulties not only in comprehending problems but also in managing their thinking during the process, largely due to limited exposure to open-ended mathematical tasks that demand deeper reasoning and reflection (Herold-Blasius, 2024).

Traditional classroom instruction often emphasizes procedural memorization over the development of higher-order thinking skills. This approach can limit students' ability to reflect on their own learning processes and adjust their strategies accordingly (Chen et al., 2024). In response, several researchers advocate incorporating metacognitive strategies that encourage students to plan, monitor, and evaluate their thinking—skills considered fundamental for building self-regulated learners (Astuti, 2024).

Empirical findings support these theoretical assertions. Studies have shown a positive relationship between metacognitive strategies and students' academic motivation and achievement, especially in mathematics (Lin & Yang, 2021; Lourenço & Paiva, 2024; Ziadat & Sakarneh, 2022). These strategies enable learners to become more autonomous and reflective, equipping them to navigate challenging tasks by adapting their approaches as needed.

For instance, Allers and Singh (2023) conducted an experimental study involving mildly gifted Grade 3 learners and found that those who used self-regulated learning strategies to study enriched, advanced-level mathematics curricula performed significantly better than peers taught through traditional direct instruction. Their findings highlight the potential of metacognitive strategies not only for general education settings but also for differentiated instruction tailored to high-ability learners.

However, the impact of metacognitive learning may vary based on individual or contextual factors. In some settings, the influence of metacognitive instruction appears limited or inconsistent, suggesting that not all students respond similarly to these strategies (Ning, 2019). Additionally, although many students benefit from such approaches, some may require more structured guidance to fully internalize and apply metacognitive practices effectively (Herold-Blasius, 2024). In conclusion, the literature highlights that metacognitive strategies can significantly enhance mathematical learning, but their effectiveness is influenced by the individual learner's needs and the broader instructional context.

The Factors that Influence the Implementation of Metacognitive Strategies

The integration of metacognitive strategies in elementary mathematics education depends on multiple interrelated factors, including individual learner characteristics, environmental conditions, and instructional design. Gender differences, for example, can influence how students engage in self-regulated learning. Research suggests that boys and girls may develop metacognitive skills differently, which has implications for how such strategies should be taught and supported in classrooms (Fajri & Amir, 2022; Ziadat & Sakarneh, 2022).

In addition to gender, learners' self-efficacy and time management skills are shown to play crucial roles in the success of metacognitive learning. Students who are confident and can manage their time effectively are more likely to engage in planning, monitoring, and reflection core elements of self-regulated learning (Lin & Yang, 2021; Lourenço & Paiva, 2024). Similarly, research conducted by Vula et al. (2017) emphasizes the importance of these elements in fostering independent learning. In alignment with these findings,

Environmental and linguistic factors also contribute to implementation challenges. Students often encounter difficulties when the mathematical language used in tasks is not clearly understood, which can obstruct both their comprehension and ability to apply metacognitive strategies (Bishara, 2016). The integration of technological support, such as interactive tools and digital platforms, has been proposed as one way to support learners—especially those who struggle with self-regulation (Dülger, 2023).

Teachers also play a critical role. The effectiveness of metacognitive instruction depends heavily on teacher preparedness, the duration of implementation, and how actively teachers engage students in reflective thinking (Hacker et al., 2019; Yang & Chiu, 2024). Professional development that equips educators with tools and strategies for supporting metacognitive growth is therefore essential.

Taken together, these findings suggest that metacognitive strategy implementation is not a one-size-fits-all solution. It requires thoughtful consideration of student diversity, classroom dynamics, and the broader educational environment to ensure that reflective learning becomes a sustainable part of mathematical instruction.

The Role of Teachers in Implementing Metacognitive Strategies

Teachers play an indispensable role in helping students develop metacognitive competence, particularly in mathematics education where reflection, planning, and reasoning are integral to conceptual understanding. Numerous studies emphasize that when teachers provide explicit instruction and model metacognitive thinking, students are more likely to internalize these processes and apply them independently during problem-solving tasks (Hacker et al., 2019).

In effective classrooms, metacognitive strategies are not taught as isolated skills but are embedded throughout instructional practices. For instance, Chiu-Lin Lai and Gwo-Jen Hwang (2016) describe how flipped classroom models allowed teachers to engage students in reflective thinking through guided activities and timely feedback. This kind of learning design promotes

active student involvement while positioning the teacher as a facilitator of learning rather than a transmitter of knowledge (Lai & Hwang, 2016)

Moreover, the role of the teacher extends to supporting students' self-questioning and articulation of mathematical reasoning. Through activities such as journaling or collaborative problem posing, teachers help learners develop the capacity to make their thinking visible and critically assess their own understanding (Yang & Chiu, 2024). These interactions encourage deeper engagement with content and foster a classroom culture of reflection.

Importantly, the evolving role of the teacher in metacognitive instruction demands a shift from control to coaching. Lin and Yang (2021) argue that teachers who embrace the role of learning facilitators, especially in technology-supported settings can more effectively promote student autonomy and engagement. This perspective is particularly relevant given the increasing integration of digital tools in mathematics instruction, which can support real-time feedback and personalized learning pathways (Chen et al., 2024).

However, it is crucial to acknowledge that students do not all benefit equally from metacognitive instruction. Herold-Blasius (2024) warns that while many students thrive under reflective approaches, others may struggle without sufficient guidance or differentiated scaffolding. Teachers, therefore, must continuously monitor students' learning processes and be ready to provide timely support based on observed needs.

Additionally, the success of metacognitive teaching depends on the teacher's own professional development and capacity to design responsive learning environments. Dülger (2023) and Lourenço & Paiva (2024) emphasize that without adequate training and ongoing support, teachers may lack the tools or confidence to implement metacognitive strategies effectively (Dülger, 2023; Lourenço & Paiva, 2024).

In sum, teachers are not merely conveyors of content, they are the architects of learning environments that foster reflective thinking. Their ability to model metacognitive processes, respond to diverse student needs, and integrate adaptive technologies significantly shapes the success of metacognitive learning in mathematics classrooms.

The Differences Between Learning Approaches Utilizing Metacognitive Strategies and Those That Do Not Incorporate

Learning approaches that integrate metacognitive strategies emphasize students' active participation in their own learning and problem-solving processes. Unlike traditional methods that focus heavily on direct instruction and rote memorization, metacognitive approaches empower learners to become self-regulated thinkers who can transfer knowledge across various contexts (Ziadat & Sakarneh, 2022). The inclusion of these strategies supports not only knowledge acquisition but also the development of critical learning behaviors such as goal setting, planning, and self-monitoring.

The presence of metacognitive strategies has been consistently linked to improved academic performance and deeper conceptual understanding. Ning (2019) notes that students who engage in planning, monitoring, and evaluating their learning processes tend to retain information more effectively. These practices help learners develop a more meaningful

connection with the content, in contrast to surface-level memorization strategies which often fail to promote long-term retention or adaptability.

Beyond academic outcomes, metacognitive approaches have also been shown to foster emotional resilience. Fajri and Amir (2022) highlight that metacognitive support can mitigate mathematics anxiety, thereby enhancing performance. Similarly, Lourenço and Paiva (2024) emphasize the role of goal setting in promoting sustained engagement and motivation during complex tasks, suggesting a close relationship between metacognitive awareness and emotional regulation in learning.

Moreover, the evaluative component of metacognitive strategies appears particularly impactful. Yang and Chiu (2024) found that students often develop stronger evaluative skills than planning or monitoring skills, indicating a progression toward more refined self-assessment capabilities. Dülger (2023) supports this by showing that self-reflection is a key mechanism through which learners adjust their approaches based on performance feedback. Such findings suggest that metacognitive strategies not only enhance immediate academic outcomes but also foster a mindset of continuous improvement.

The absence of metacognitive practices, by contrast, can impede learning. Without these strategies, students may struggle to articulate their reasoning, justify their answers, or recognize gaps in their understanding—leading to a fragmented and shallow grasp of knowledge (Hacker et al., 2019). This limitation underscores the essential role of metacognition in developing both cognitive flexibility and transferability of knowledge.

Taken together, these studies converge on the conclusion that metacognitive strategies are integral to effective learning. While individual contributions differ in focus—ranging from academic achievement to emotional resilience—the collective evidence affirms the multifaceted benefits of fostering metacognitive awareness in educational settings (Chatzistamatiou et al., 2015).

Table 4. Summary of Key Findings by Source

| Author(s) | Year | Key Finding |
|---------------------|------|--|
| Herold-Blasius | 2024 | Metacognitive strategies enhance reflection but need scaffolding for some learners. |
| Chen et al. | 2024 | Traditional teaching lacks reflection; metacognitive strategies support higher order thinking. |
| Astuti | 2024 | Planning, monitoring, and evaluation improve problem solving. |
| Lin and Yang | 2021 | Metacognitive practices increase student motivation and self direction. |
| Lourenço and Paiva | 2024 | Goal setting enhances metacognitive awareness and sustained engagement. |
| Ziadat and Sakarneh | 2022 | Metacognitive learning supports deeper understanding and absence limits flexibility. |
| Allers and Singh | 2023 | Self-regulated learners outperformed peers in enriched math curriculum. |
| Ning | 2019 | Not all students respond equally; contextual factors matter. |
| Fajri and Amir | 2022 | Metacognitive support reduces math anxiety and enhances outcomes. |

| Author(s) | Year | Key Finding |
|------------------------|------|--|
| Bishara | 2016 | Mathematical language clarity affects strategy application. |
| Dülger | 2023 | Tech tools assist learners with low self-regulation; teacher training is critical. |
| Hacker et al. | 2019 | Lack of metacognition leads to shallow understanding and limited reasoning. |
| Yang and Chiu | 2024 | Evaluation skills often develop first; helps learners adjust strategies. |
| Lai and Hwang | 2016 | Reflective tasks and feedback in flipped models support metacognition. |
| Vula et al. | 2017 | Time use and self-direction strongly predict metacognitive success. |
| Chatzistamatiou et al. | 2015 | Metacognitive awareness contributes to long term academic success. |

As seen in **Table 4**, diverse research perspectives converge on the conclusion that metacognitive strategies, especially those involving planning, monitoring, and evaluation enhance learners' ability to think reflectively and perform more effectively in mathematics. These strategies not only improve academic achievement but also support emotional resilience, such as reducing math anxiety and increasing motivation.

However, the findings also reveal that the effectiveness of metacognitive learning is not universal. Some students, especially those with low self-efficacy or unfamiliarity with reflective tasks, may struggle to apply these strategies without structured guidance (Herold-Blasius, 2024; Ning, 2019). This indicates the need for differentiated scaffolding and ongoing support in classroom instruction.

Teachers play a crucial role as facilitators of metacognitive development. Studies highlight the importance of teacher modeling, timely feedback, and integration of digital tools (Yang & Chiu, 2024; Lai & Hwang, 2016). Without sufficient training, however, many educators may lack the resources or confidence to implement such strategies effectively.

In contrast, students taught under traditional, non-metacognitive approaches tend to develop only surface-level understanding and struggle with transferring knowledge across contexts. This stark difference reinforces the necessity of embedding metacognitive practices into both instruction and curriculum planning.

Overall, the synthesis of findings supports the argument that metacognitive strategies are essential for fostering both cognitive and emotional growth in mathematics learning. Future research should explore how these strategies can be sustained over time and adapted to diverse learning environments.

Discussion

This study highlights the significant impact of metacognitive strategies on primary students' mathematical understanding and self-regulation. The reviewed literature consistently shows that students who use planning, monitoring, and evaluation strategies perform better and engage more deeply in learning. These strategies enable students to reflect on their reasoning, adjust their problem-solving approaches, and persist through challenges skills that are crucial in navigating mathematical tasks that often involve abstract concepts and complex language. For

instance, difficulties in interpreting problem statements or identifying unknown variables can hinder students' progress, yet metacognitive reflection helps them recognize such obstacles and find more effective strategies (Wong & Yip, 2023; Bishara, 2016). Moreover, by fostering greater awareness of their cognitive processes, students become more autonomous and confident learners. However, these benefits are not uniform; as highlighted in the reviewed studies, some learners particularly those with low self-efficacy or limited exposure to reflective learning require structured support and teacher scaffolding to apply these strategies effectively (Herold-Blasius, 2024; Ning, 2019). This suggests that while metacognitive strategies are powerful tools for mathematical learning, their success depends on careful implementation that takes into account students' individual differences and learning environments.

Teachers play a critical role in implementing these strategies. Their ability to model and embed metacognitive thinking into daily instruction influences how well students adopt reflective learning habits. Several studies in this review demonstrate that teachers who receive targeted training in self-regulated and metacognitive instruction are more effective in promoting student engagement and autonomy. For instance, Dülger (2023) shows that when teachers use classroom analytics tools to monitor students' self-regulated learning behaviors, they can tailor their instruction more precisely, leading to improved metacognitive outcomes. In contrast, Herold-Blasius (2024) and Lourenço & Paiva (2024) highlight that teachers without adequate support or professional development often overlook essential phases such as evaluation, resulting in less effective implementation. These findings suggest that trained teachers are better equipped to provide scaffolding, feedback, and opportunities for reflection. As the role of the teacher shifts from content deliverer to learning facilitator, their capacity to guide metacognitive development becomes central to instructional success. This transformation underscores the need for continuous professional development focused on metacognitive strategies, particularly in diverse classroom settings.

In addition to cognitive gains, metacognitive strategies contribute to emotional outcomes such as reduced math anxiety and increased motivation. When students understand how to monitor and evaluate their own thinking, they gain a stronger sense of control over the learning process, something that can ease the stress often associated with mathematics. As shown by Fajri and Amir (2022), students who received metacognitive support experienced lower levels of anxiety, especially when they had access to clear and structured strategies for approaching problems (Fajri & Amir, 2022). This suggests that anxiety in math may not only be about the content itself, but also about feeling unsure of how to begin or move forward. Interestingly, evaluative metacognition, the ability to reflect on one's performance, often develops earlier than planning or monitoring skills, making it a valuable starting point in building students' confidence. Practically, integrating metacognitive instruction into mathematics lessons can also serve as an entry point for fostering students' social-emotional competencies. When students are guided to reflect and manage their learning, they are not only improving their academic skills but also developing emotional resilience, which is crucial for long-term engagement with the subject (Vula et al., 2017).

By contrast, traditional approaches that lack metacognitive elements often lead to superficial learning and limited knowledge transfer. These methods typically focus on procedural memorization, offering little space for students to reflect on their thinking or develop flexible problem-solving strategies (Chen et al., 2024; Hacker et al., 2019). Despite growing

evidence supporting metacognitive instruction, traditional teaching remains dominant in many classrooms. This persistence may be due to several practical challenges: many teachers have not received sufficient training in metacognitive pedagogy (Lourenço & Paiva, 2024), classroom routines are often designed around rigid curricula, and schools in under-resourced settings may lack the tools needed to support reflective learning (Zhang & Lian, 2024). Additionally, shifting to metacognitive approaches requires a fundamental change in mindset from delivering content to facilitating thinking which can be difficult without ongoing support. These factors highlight that embedding reflective practices in mathematics education is not only important but also complex. Ultimately, while metacognitive strategies have the potential to transform learning, their success relies on thoughtful implementation, teacher readiness, and a supportive learning environment that addresses the diverse needs of students.

CONCLUSION

Conclusion

Based on the results of the literature review on metacognitive strategies in mathematics learning in elementary schools, it can be concluded that these strategies have a significant impact on improving students' mathematical problem-solving skills and academic achievement. The application of metacognitive strategies helps students to self-regulate their learning, increase motivation and deepen understanding of mathematical concepts. However, the effectiveness of these strategies may vary depending on factors such as gender differences, self-efficacy, environmental conditions and technological support. Teachers play a critical role in the effective application of metacognitive strategies by offering clear instructional guidance, modeling cognitive processes, and fostering active student engagement in learning. It's important for educators to adjust their teaching styles to cater to the varied needs of their students. Furthermore, studies reveal that learning techniques that include metacognitive strategies are notably more effective than traditional methods that depend on memorization. These strategies assist students in becoming more aware of their own thinking processes and boost their problem-solving skills. However, this SLR is limited by the scope of its database selection, language constraints, and the exclusion of unpublished or non-peer-reviewed literature, which may affect the comprehensiveness of the findings.

Recommendations

To boost the effectiveness of metacognitive strategies in elementary math learning, it's essential to elevate the support teachers receive through continuous training. This training is designed to empower teachers with a solid grasp of metacognitive strategies and how to teach them in a fun way to their students. Furthermore, incorporating technology into the learning process is also a vital component in supporting the application of these strategies. Utilizing engaging apps and digital resources can foster a lively learning atmosphere and assist students in managing their own educational journeys with confidence. Moreover, it's crucial to embrace a personalized learning approach since each student has unique strengths and challenges when it comes to applying metacognitive strategies. By being more flexible and responsive in our teaching styles, we can ensure that every student enjoys the benefits of these strategies in a manner that aligns with their personal needs. Lastly, additional research is needed to examine how effective metacognitive strategies are across various educational environments. This research can provide insights into how elements like socioeconomic status and access to

educational tools influence the successful application of these strategies, enabling us to create even more effective solutions to enhance student learning outcomes.

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