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## Innovation for Enhancing Students' Mathematical Reasoning: A Systematic Literature Review

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### Article Info

Article history:

Received: January 8<sup>th</sup>, 2026

Revised: January 29<sup>th</sup>, 2026

Accepted: January 29<sup>th</sup>, 2026

Available online: January 31<sup>st</sup>, 2026

<https://doi.org/10.33541/edumatsains.v10i3.7763>

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### Abstract

This research is a systematic literature review that explores current trends and various innovations aimed at enhancing students' mathematical reasoning abilities. The purpose of this study is to map previous research developments related to mathematical reasoning and to identify gaps that remain in the existing literature. A total of 200 prior studies published in journals and conference proceedings between 2019–2024 were collected via Google Scholar using the Publish or Perish application. The data were analysed using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework with the assistance of Covidence (<https://www.covidence.org/>). From the initial 200 studies, 149 were excluded at the title and abstract screening stage because they did not address innovations related to mathematical reasoning, while 15 others were removed due to inappropriate research designs. This left 36 studies that were examined in greater depth to identify emerging trends and forms of innovation used to improve mathematical reasoning. The majority of these studies were conducted in 2020, totalling 11 studies. Most research subjects were Grade VIII junior high school students, appearing in 12 studies. The quasi-experimental method was the most frequently applied research design, used in 23 studies. The most common form of innovation identified was the application of learning models, found in 17 studies. Other innovations included the use of varied approaches and methods, integration of information and communication technology, and the development of instructional media.

**Keywords:** Innovation, Mathematical Reasoning, PRISMA, Systematic literature review

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## 1. Introduction

Mathematical reasoning is one of the key components in mathematics learning. It relates to the ability to recognize and analyse patterns, and to use such analysis to examine the validity of a conjecture (Kemendikbudristek RI, 2024; NCTM, 2000). Mathematical reasoning activities involve using knowledge about mathematical objects (Brodie, 2009) to assess the relationship between a given problem and certain mathematical objects or concepts (Kilpatrick et al., 2001), so that appropriate problem-solving strategies can be selected (OECD, 2018). For this reason, mathematical reasoning has been designated as one of the process standards in mathematics education by NCTM (2000). Mathematical reasoning supports intellectual development that facilitates progress in technology, engineering, science, business, and government, and enables individuals to participate fully in society (Kilpatrick et al., 2001). A person's reasoning activity forms the basis of mathematical cognitive development (Morsanyi et al., 2018). This makes mathematical reasoning an important factor in enhancing conceptual understanding (Jonsson et al., 2020) and students' learning outcomes (Samad & Assaibin, 2021; Setiawan, 2016), as well as serving as a foundation for the development of other abilities such as mathematical literacy (Kusumawardani et al., 2018) and mathematical proof skills (Hendana & Lestari, 2024).

However, the importance of mathematical reasoning is not yet reflected in current conditions. Previous studies have revealed that Indonesian students' mathematical reasoning skills remain relatively low. Aprilianti & Zanthi (2019) reported that more than 50% of junior high school students demonstrated low mathematical reasoning ability. This finding is supported by Ramdan & Roesdiana (2022), who showed that the average student performance on mathematical reasoning tests was only 20.63%. This low performance is attributed to students' weak conceptual understanding of related material (Isnaeni et al., 2018), limited ability to construct proofs, inadequate skills in providing logical explanations for solutions, and difficulty in drawing appropriate conclusions. This condition can affect students' achievement in mathematics learning, especially in solving non-routine problems that require logical reasoning, strategic problem solving, and drawing conclusions based on available information (Mulyana et al., 2025).

To overcome these challenges, numerous innovations have been implemented. Innovation refers to new ideas, methods, or tools that can be applied across various fields to produce improvements (Syafaruddin et al., 2012). In the context of mathematical reasoning, innovation aims to enhance students' reasoning abilities. Such innovations may take the form of implementing different learning models and approaches, or incorporating media and technology into instruction. This study aims to identify research trends related to innovations implemented to improve mathematical reasoning skills. A systematic literature review is needed as a foundation for further research on innovation efforts to strengthen students' mathematical reasoning ability.

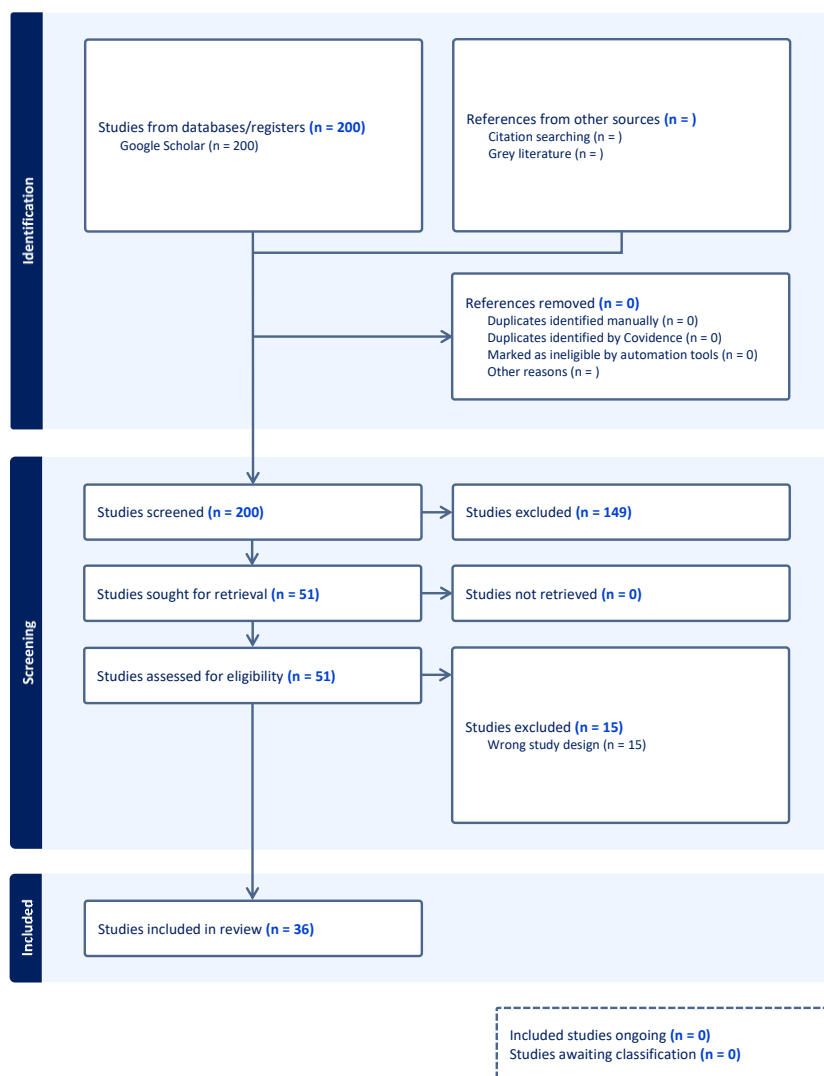
## 2. Methods

This study is a systematic literature review that was conducted in a structured and planned manner (Hemingway, 2009) with the aim of answering specific, focused, and relevant research questions, as well as identifying research gaps in previous studies. Prior research data were obtained using Harzing's Publish or Perish software with the keywords "penalaran matematis" and

“mathematical reasoning.” A total of 200 articles indexed in Google Scholar and published between 2019 and November 10, 2024 were collected. These 200 articles were then further analysed using the PRISMA method with the assistance of the Covidence website (<https://www.covidence.org/>).

PRISMA, an acronym for *Preferred Reporting Items for Systematic Reviews and Meta-Analyses*, serves to enhance the transparency of the research process, ensure the reliability and validity of review findings, reduce bias, support comprehensive reporting, and meet established methodological guidelines, thereby improving the overall quality of systematic reviews and meta-analyses (Page et al., 2021; Rethlefsen et al., 2021). The PRISMA flowchart is presented in Figure 1.

**Figure 1.**  
*PRISMA Flow Diagram*



Of the 200 articles obtained, 149 were excluded at the title and abstract screening stage because they were qualitative analytical studies on students' mathematical reasoning and did not include innovations related to improving mathematical reasoning. A further 15 articles were excluded during the screening stage because they were literature review studies on improving mathematical reasoning, which did not match the type of study required in this review. In the end, 36 articles were identified as containing innovations aimed at enhancing mathematical reasoning.

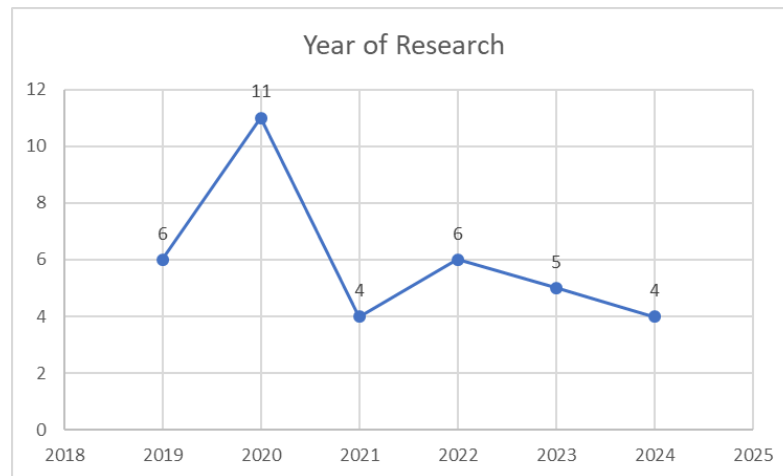
### 3. Result and Discussion

#### Research Trends from 2019–2024

The studies reviewed in this research were conducted between 2019 and 2024. Figure 2 below shows the distribution of the number of studies conducted each year during this period.

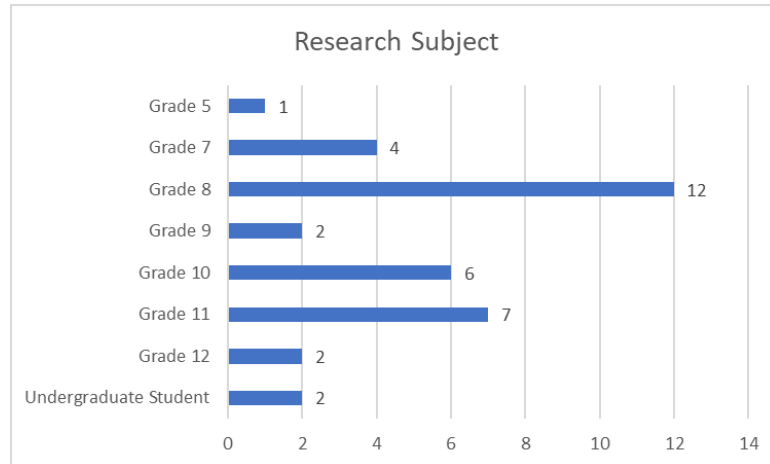
**Figure 2.**

*Distribution of Research by Year*



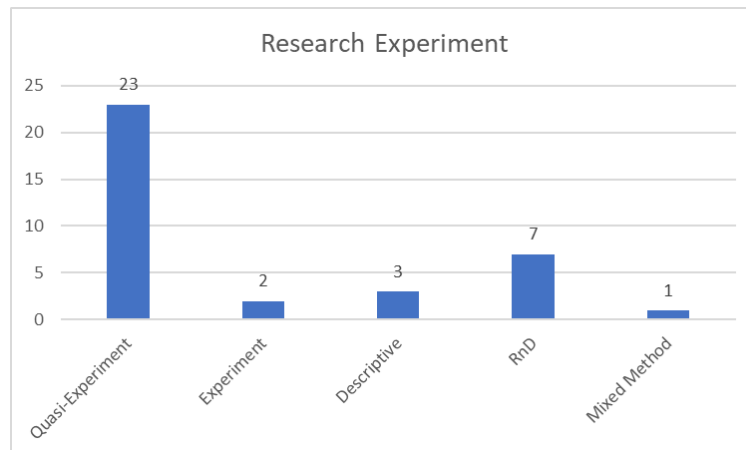
From Figure 2, it can be concluded that research on innovations to improve mathematical reasoning was conducted most frequently in 2020, with a total of 11 studies. Studies related to innovations in mathematical reasoning show a declining trend from 2020 to 2024. Based on research subjects, studies on innovations to improve mathematical reasoning most often involved junior high school students, particularly those in Grade VIII. There were 12 previous studies that involved Grade VIII students as research subjects. The least frequently involved subjects were elementary school students, with only one previous study including them as participants. Figure 3 below presents the distribution of research based on the research subjects.

**Figure 3.**  
*Distribution of Research Based on Subjects*



The most widely used research method was the quasi-experimental method, which was applied in 23 previous studies. Meanwhile, the least used method was the mixed-method approach, with only one prior study employing this design. Figure 4 below presents a chart showing the distribution of previous studies based on the research methods used.

**Figure 4.**  
*Distribution of Research Based on Research Methods*



## **Variations of Innovations to Improve Mathematical Reasoning**

Based on the previous studies reviewed, it was found that the innovations implemented in learning to enhance students' mathematical reasoning abilities can generally be grouped into learning models, learning approaches, learning methods, the use of information and communication technology, as well as the use of specific learning media and tools. The findings of prior studies indicate a significant improvement in students' mathematical reasoning abilities when learning is carried out using these innovations.

### **Learning Models**

The most common strategy used in previous research to improve mathematical reasoning was the application of specific learning models. A total of 17 prior studies employed particular learning models in efforts to develop students' mathematical reasoning skills. These models included Problem-Based Learning (PBL) (Apriani, 2020; Nababan, 2020; Rhofiqah & Thaariq, 2019), Project Based Learning (PjBL) (Abidin et al., 2020), and Discovery Learning (Mendrofa & Mendrofa, 2022). Other models include the Knisley model, which aims to help students develop new concepts based on previously acquired knowledge (Lestari & Sardin, 2020); the Connected Mathematics Project model, which strengthens mathematical competence by enriching students' understanding of the relationship between mathematics and other disciplines (Aprillia & Lestari, 2022); and the Reciprocal Teaching model, which encourages students to actively construct their cognition through activities such as understanding texts and communicating them to peers (Andira et al., 2024).

Cooperative learning models have also been implemented. Cooperative learning may be combined with the AIR model (Auditory, Intellectuality, Repetition), which emphasizes knowledge construction through listening, reasoning, expressing ideas, and solving problems (Nuralam & Maulidayani, 2020). Another cooperative model is TAPPS (Think Aloud Pair Problem Solving), in which students work in pairs, with one acting as a listener and the other as a problem solver (Sari et al., 2020). The NHT (Numbered Heads Together) cooperative model involves dividing students into groups and assigning each member a number and corresponding responsibility, ensuring that each student contributes to completing the task and earns credit for the group (Jelatu et al., 2019).

### **Learning Approaches**

Several prior studies also employed specific approaches to enhance mathematical reasoning. One such approach is the open-ended approach, implemented through the use of open-ended problems (Raharjo et al., 2020). Eliza et al. (2023) applied a metaphorical thinking approach that connects problem-solving tasks with real-life situations, making initially abstract problems more concrete. Another approach is the contextual approach, which stimulates students to actively explore their understanding and academic abilities through various contexts inside and outside the classroom (Rio Febrianto & Rudy, 2019; Yunus et al., 2020). The LSLC (Lesson Study for Learning Community) approach integrated with PMRI (Indonesian Realistic Mathematics Education) creates an innovative and inclusive learning environment through active collaboration

among teachers, students, and the school community (Octriana et al., 2019). Meanwhile, the metacognitive approach emphasizes the use of contextual problems mediated by teachers so that students can actively construct (reinvent) their knowledge (Syaripuddin et al., 2020).

### **Learning Methods**

Mathematical reasoning is related to connecting the problems at hand with certain mathematical concepts. To be able to link problems with concepts, a person must of course understand and remember the basic concepts that will be used. However, many students still struggle to remember concepts, so their reasoning activities do not run optimally. Research conducted by Heryani et al. (2021) explored the use of the Mnemonic Method (from the Greek word *mnemonikos*), a method to improve students' memory by associating information to be remembered with certain imaginative forms. This method coordinates both the left and right brain simultaneously, enabling students to gain more comprehensive knowledge.

### **Use of Information and Communication Technology**

The utilization of advances in Information and Communication Technology (ICT) in mathematics learning has facilitated the development and improvement of students' learning outcomes. Several examples of ICT use to enhance mathematical reasoning include the use of Google Classroom as a Learning Management System (LMS) (Santosa et al., 2020), the development of game applications containing practice exercises (Diwimuri & Soebagyo, 2022), and the use of Microsoft PowerPoint in developing interactive learning media (Rosmayanti & Zanthi, 2019).

### **Learning Media**

Learning media are tools that teachers can use to deliver material to students, allowing material to be presented in a more concrete, comprehensive, and engaging form. One type of learning media that can be used to improve mathematical reasoning is Student Worksheets (Lembar Kerja Peserta Didik, LKPD). The presentation of these worksheets can be combined with the Realistic Mathematics Education (RME) approach (Yanti et al., 2022), the discovery learning model (Yadrika et al., 2022), or integrated with the flipped classroom model and complemented with lesson plans and instructional videos (Fedistia & Musdi, 2020).

## **4. Conclusion**

The highest number of studies aiming to improve mathematical reasoning through the application of specific innovations was conducted in 2020, totalling 11 studies. The most frequently involved research subjects in previous studies were eighth-grade junior high school students, with 12 studies. The research method most commonly used was quasi-experimental design, appearing in 23 studies. The most widely applied innovation to improve mathematical reasoning was the use of specific learning models, with 17 studies. In addition, the use of different learning approaches, learning methods, information and communication technology, as well as learning media also successfully improved students' mathematical reasoning significantly. One of the limitations of this study is the restricted availability of previous research sources. Future studies may expand the

scope of the reviewed data by including studies indexed in Scopus or other databases. The study period may also be extended beyond the range of 2019 to 2024.

## 5. Acknowledgments

The authors would like to express their gratitude to all parties who have contributed to and supported this research.

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