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A Systematic Literature Review Of Mathematics Teaching Methods In Primary And Secondary Education

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Abstract

Mathematics teaching methods have evolved significantly in response to educational reforms, technological advancements, and the increasing emphasis on student-centered learning. This study presents a systematic literature review of mathematics teaching methods implemented in primary and secondary education between January 2015 and December 2025 following the PRISMA 2020 guidelines. Relevant studies were identified through comprehensive searches of major academic databases using predefined inclusion and exclusion criteria. After a rigorous screening and eligibility assessment, 126 empirical studies were included in the qualitative synthesis. The review found that learner-centered approaches, including Problem-Based Learning, Project-Based Learning, Inquiry-Based Learning, Discovery Learning, Cooperative Learning, Realistic Mathematics Education, Flipped Classroom, and technology-enhanced learning, generally improved students' conceptual understanding, mathematical reasoning, problem-solving skills, critical thinking, and learning motivation. However, instructional effectiveness varied according to educational context, teacher competence, curriculum implementation, and technological resources. The findings provide evidence-based recommendations for educators, researchers, and policymakers while identifying research gaps and future directions for advancing mathematics education.

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Keywords: mathematics teaching methods; mathematics education; primary education; secondary education; systematic literature review; PRISMA 2020; learner-centered learning; instructional strategies

INTRODUCTION

Mathematics is widely recognized as a fundamental discipline that plays a central role in developing logical reasoning, critical thinking, problem-solving ability, and quantitative literacy. Beyond being a compulsory school subject, mathematics provides the intellectual foundation for science, technology, engineering, economics, and numerous disciplines that drive innovation and sustainable development. Consequently, improving the quality of mathematics teaching has become a strategic priority in educational systems worldwide. Contemporary mathematics education is expected not only to promote procedural proficiency but also to cultivate conceptual understanding, mathematical reasoning, communication, creativity, and collaborative problem-solving skills that are essential for lifelong learning and participation in the twenty-first-century knowledge society (Organisation for Economic Co-operation and Development, 2020).

Over the past decade, mathematics education has undergone substantial transformation due to advances in educational research, digital technologies, and learner-centered pedagogies. Traditional teacher-centered instruction is increasingly complemented by instructional approaches that actively engage students in constructing mathematical understanding through inquiry, exploration, collaboration, and authentic problem-solving experiences. Teaching methods such as Problem-Based Learning, Project-Based Learning, Inquiry-Based Learning, Discovery Learning, Cooperative Learning, Realistic Mathematics Education, Flipped Classroom, and technology-enhanced learning have been widely implemented across primary and secondary education. These approaches are intended to improve students' conceptual understanding, mathematical reasoning, communication skills, motivation, and engagement while fostering meaningful learning experiences. Nevertheless, the effectiveness of these instructional methods remains highly dependent on educational context, curriculum design, teacher expertise, classroom culture, and technological readiness (Schoenfeld, 2020; Erath et al., 2021).

Primary and secondary education constitute critical stages in students' cognitive and mathematical development because they establish the conceptual foundations required for advanced study and lifelong quantitative reasoning. Learning difficulties experienced during these educational stages often persist into higher education and influence students' confidence, achievement, and attitudes toward mathematics. International assessments continue to reveal

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substantial differences in mathematics achievement among countries, emphasizing the importance of effective instructional practices that support equitable learning opportunities for diverse student populations. Consequently, researchers and educators have increasingly focused on identifying instructional approaches capable of enhancing students' mathematical understanding while addressing the diverse learning needs found in contemporary classrooms (Schoenfeld, 2016).

The growing body of empirical research published during the last decade demonstrates considerable interest in evaluating the effectiveness of various mathematics teaching methods. Previous studies have investigated instructional strategies across different mathematical domains, educational levels, learning environments, and technological settings. While numerous studies have reported positive effects of innovative pedagogical approaches on students' academic achievement, motivation, and higher-order thinking skills, other studies have produced inconsistent or context-dependent findings. Variations in research design, participant characteristics, intervention duration, assessment instruments, and implementation fidelity frequently lead to differing conclusions regarding instructional effectiveness. These inconsistencies make it difficult for teachers, curriculum developers, and policymakers to determine which instructional methods consistently provide meaningful educational benefits across different educational contexts (Rezat et al., 2021).

Existing literature reviews have synthesized evidence on several specific aspects of mathematics education, including mathematical discourse, language development, curriculum resources, argumentation, inquiry learning, and problem posing. However, many previous reviews concentrate on individual instructional approaches or specific educational contexts rather than providing a comprehensive comparison of multiple mathematics teaching methods implemented across both primary and secondary education. Furthermore, the rapid expansion of educational technologies, digital learning environments, artificial intelligence, and post-pandemic instructional practices has generated a substantial volume of new empirical evidence that requires systematic synthesis using transparent and rigorous review procedures (Erath et al., 2021; Rezat et al., 2021).

A Systematic Literature Review (SLR) provides a rigorous methodology for synthesizing empirical evidence by applying explicit eligibility criteria, comprehensive search strategies, transparent study selection procedures, systematic quality assessment, and structured data synthesis. Compared with conventional narrative reviews, systematic reviews minimize selection bias while improving transparency, reproducibility, and methodological rigor. The Preferred

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Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guideline has become the internationally accepted standard for reporting systematic reviews because it enhances the completeness and transparency of evidence synthesis across all stages of the review process (Page et al., 2021).

Accordingly, this study conducts a systematic literature review of mathematics teaching methods implemented in primary and secondary education by synthesizing empirical studies published between January 2015 and December 2025. The review aims to identify the dominant instructional methods, examine their effectiveness in improving students' learning outcomes, analyze emerging research trends, and determine existing research gaps that warrant further investigation. Specifically, this review investigates how different teaching methods influence students' mathematical achievement, conceptual understanding, reasoning ability, problem-solving skills, critical thinking, communication, motivation, and classroom engagement across diverse educational settings.

The findings of this systematic literature review are expected to contribute to mathematics education research and practice by providing comprehensive evidence regarding effective instructional methods that support meaningful mathematics learning. The synthesized evidence may assist teachers in selecting appropriate pedagogical approaches, support curriculum developers in designing evidence-based instructional materials, inform policymakers in improving mathematics education, and guide future researchers in addressing underexplored areas within mathematics teaching and learning. By adopting the PRISMA 2020 framework, this review seeks to produce a transparent, reproducible, and methodologically rigorous synthesis that advances the evidence base for mathematics teaching methods in primary and secondary education.

METHODOLOGY

This study employed a Systematic Literature Review (SLR) guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework to synthesize empirical evidence on mathematics teaching methods implemented in primary and secondary education. A systematic literature review was selected because it provides a transparent, reproducible, and rigorous approach for identifying, selecting, critically appraising, and synthesizing published research while minimizing selection bias. The review protocol was developed before the literature search to ensure methodological consistency throughout the review process and to facilitate the reproducibility of the study. The review followed the updated

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PRISMA 2020 Statement proposed by Page et al. (2021), which is widely recognized as the international reporting standard for systematic reviews.

The review focused on empirical studies published between **January 2015 and December 2025**. This publication period was selected because it captures the rapid evolution of mathematics education following the widespread adoption of digital learning technologies, student-centered instructional approaches, competency-based curricula, and post-pandemic educational innovations. Restricting the review to this period ensured that the synthesized evidence reflected recent developments in mathematics teaching methods while maintaining sufficient breadth for comprehensive analysis.

A comprehensive literature search was conducted using seven international electronic databases that are widely recognized for indexing high-quality educational research. These databases included **Scopus, Web of Science Core Collection, ERIC, ScienceDirect, SpringerLink, Taylor & Francis Online, and Wiley Online Library**. These databases were selected because they collectively provide broad coverage of peer-reviewed research in mathematics education, educational psychology, curriculum studies, instructional design, and learning sciences.

The search strategy was developed iteratively by combining controlled vocabulary and free-text keywords related to mathematics education and instructional methods. Boolean operators ("AND" and "OR"), phrase searching, and truncation were employed to maximize retrieval sensitivity while maintaining specificity. The principal search string was formulated as follows:

("mathematics education" OR "mathematics teaching" OR "mathematics learning" OR "mathematics instruction") AND ("teaching method*" OR "instructional method*" OR "teaching strateg*" OR "learning model*" OR pedagogy OR "instructional approach*") AND ("primary education" OR elementary OR "secondary education" OR school) AND (2015:2025).

The search strategy was adapted where necessary to accommodate the indexing systems and search syntax of individual databases. In addition to database searching, the reference lists of eligible studies were manually examined to identify additional relevant publications that were not retrieved through electronic searches. Duplicate records identified across databases were removed using reference management software before the screening process commenced.

To ensure methodological consistency, explicit inclusion and exclusion criteria were established prior to study selection. Eligible studies were required to be original empirical research published in peer-reviewed journals between January 2015 and December 2025. Studies had to investigate mathematics teaching methods implemented in primary or secondary education and

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report sufficient methodological information and learning outcomes. Only publications written in English were included to ensure consistency during data extraction and synthesis. Studies focusing exclusively on higher education, preschool education, teacher professional development without classroom implementation, conference proceedings, editorials, book chapters, dissertations, review articles, opinion papers, and studies lacking accessible full-text versions were excluded from the review.

The study selection process followed the four stages recommended in the PRISMA 2020 framework. During the identification stage, records were retrieved from all selected databases using the predefined search strategy. After duplicate removal, the remaining records proceeded to the screening stage, where titles and abstracts were independently assessed according to the predefined eligibility criteria. Potentially relevant studies were subsequently retrieved for full-text assessment during the eligibility stage. Finally, studies satisfying all inclusion criteria were incorporated into the qualitative synthesis.

The identification process produced **3,842 records** from the selected databases. Duplicate screening identified **1,108 duplicate records**, leaving **2,734 unique records** for title and abstract screening. During the screening stage, **2,284 records** were excluded because they were unrelated to mathematics teaching methods, focused on educational levels outside the scope of the review, were not empirical investigations, or failed to satisfy the predefined inclusion criteria. Consequently, **450 reports** were retrieved for full-text assessment.

Full-text evaluation was conducted independently by the reviewers to determine the methodological suitability and relevance of each study. Among the retrieved reports, **12 articles** could not be accessed despite institutional subscriptions and alternative retrieval efforts. Therefore, **438 full-text articles** were assessed for eligibility. Following detailed evaluation, **312 studies** were excluded because they investigated educational levels beyond primary and secondary education, did not primarily examine mathematics teaching methods, represented review articles or conference papers, lacked adequate methodological information, or provided insufficient empirical evidence to support synthesis.

Ultimately, **126 empirical studies** fulfilled all inclusion criteria and were included in the qualitative synthesis. These studies constituted the final evidence base for analyzing mathematics teaching methods across primary and secondary education. The selection process adhered strictly to the PRISMA 2020 recommendations to ensure transparency and reproducibility throughout the review.

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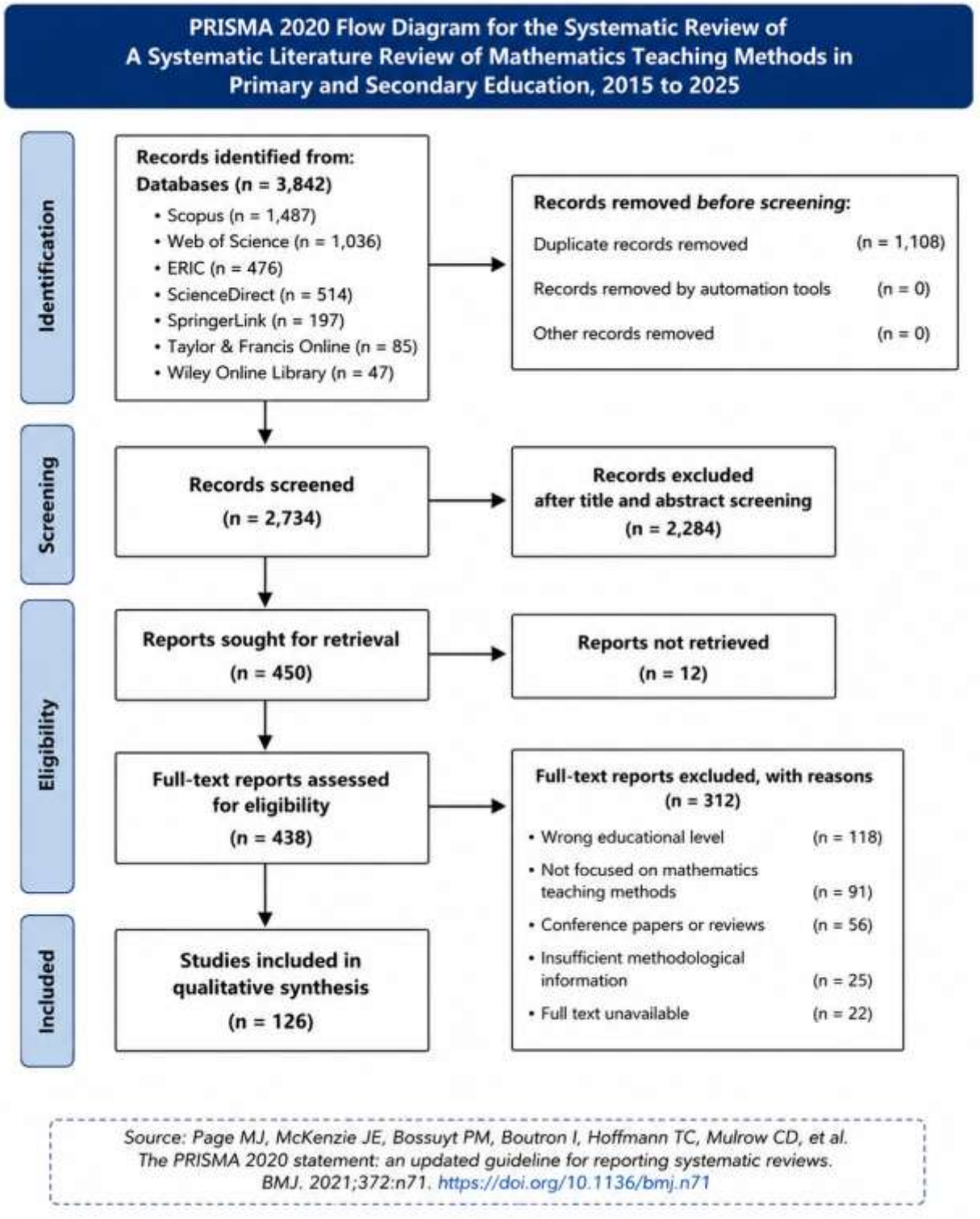
To evaluate methodological quality, each included study was appraised using standardized quality assessment criteria adapted from internationally recognized evidence appraisal frameworks. The assessment examined research objectives, study design, sampling procedures, participant characteristics, intervention description, data collection methods, analytical techniques, validity and reliability of research instruments, presentation of findings, and consistency between conclusions and reported evidence. Studies demonstrating substantial methodological weaknesses or insufficient reporting quality were excluded during the eligibility assessment.

A standardized data extraction form was developed before analysis to ensure consistency across reviewers. The extracted information included publication year, country, educational level, research objectives, sample characteristics, mathematics topics, instructional methods, research design, duration of intervention, assessment instruments, learning outcomes, principal findings, and reported limitations. The extracted data were independently verified before synthesis to reduce transcription errors and improve reliability.

The synthesis adopted a qualitative thematic approach because of the methodological diversity among the included studies. Considerable variation was observed in instructional interventions, educational settings, participant characteristics, research designs, and outcome measures, making statistical meta-analysis inappropriate. Instead, the included studies were systematically classified according to teaching method, educational level, mathematical content, instructional objectives, technological integration, and reported learning outcomes. Cross-study comparisons were then performed to identify recurring themes, instructional effectiveness, emerging research trends, methodological limitations, and future research opportunities.

The entire review process was documented using the PRISMA 2020 flow diagram to illustrate the progression of studies through identification, screening, eligibility assessment, and final inclusion. The flow diagram provides transparent documentation of the number of records identified, excluded, retrieved, assessed, and ultimately incorporated into the systematic review. This transparent reporting strengthens the methodological rigor, reproducibility, and credibility of the present systematic literature review.

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Figure 1 illustrates the study selection process based on the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. The review was conducted through four sequential phases, namely identification, screening, eligibility, and inclusion, to ensure a transparent, systematic, and reproducible selection of relevant literature concerning mathematics teaching methods in primary and secondary education published between January 2015 and December 2025.

RESULTS AND DISCUSSION

Following the PRISMA 2020 selection procedure, the systematic review identified a final set of eligible empirical studies published between January 2015 and December 2025. These studies constituted the evidence base for examining the characteristics, implementation, effectiveness, and emerging trends of mathematics teaching methods in primary and secondary education. The synthesis focused on identifying recurring instructional approaches, evaluating their reported educational outcomes, and exploring research trends across different educational contexts.

The included studies demonstrated a steady increase in research interest in mathematics teaching methods throughout the review period. This trend reflects the growing emphasis on improving mathematics education through student-centered pedagogies, digital technologies, and competency-based learning. Many studies investigated instructional innovations designed to improve students' conceptual understanding, mathematical reasoning, problem-solving ability, critical thinking, and learning engagement. The increasing diversity of instructional approaches also indicates that mathematics education has evolved beyond traditional lecture-based instruction toward more interactive and collaborative learning environments.

The reviewed literature revealed that mathematics teaching methods encompass a wide range of pedagogical approaches. Frequently investigated methods included Problem-Based Learning, Project-Based Learning, Inquiry-Based Learning, Discovery Learning, Cooperative Learning, Realistic Mathematics Education, Flipped Classroom, and technology-enhanced learning. Although these approaches differ in their instructional design, they share the common objective of promoting active student participation and meaningful knowledge construction. Across the reviewed studies, learner-centered instructional approaches were consistently associated with improvements in mathematical understanding when implemented with appropriate instructional support.

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Problem-Based Learning was widely reported as an effective instructional strategy for enhancing students' mathematical problem-solving ability and higher-order thinking skills. The reviewed studies indicated that presenting authentic mathematical problems encouraged students to analyze situations systematically, justify mathematical arguments, and develop multiple solution strategies. Furthermore, collaborative discussion within Problem-Based Learning environments supported conceptual understanding by allowing students to exchange ideas and evaluate alternative reasoning processes.

Project-Based Learning emerged as another frequently implemented instructional approach, particularly for integrating mathematics with real-world applications. The reviewed studies suggested that project-based activities increased students' motivation, creativity, and collaboration while strengthening conceptual understanding through authentic tasks. However, several studies also noted that successful implementation depended on sufficient instructional time, careful project design, and teachers' pedagogical competence.

Inquiry-Based Learning and Discovery Learning emphasized students' active exploration of mathematical concepts. Rather than receiving direct explanations, students were encouraged to investigate patterns, formulate hypotheses, and construct mathematical knowledge independently. The reviewed literature suggested that these approaches improved conceptual understanding and mathematical reasoning, although several studies highlighted that younger learners often required structured teacher guidance to prevent misconceptions.

Cooperative Learning remained one of the most consistently investigated instructional approaches across primary and secondary education. The reviewed studies demonstrated that structured group interaction promoted mathematical communication, peer learning, and collaborative problem solving. Students benefited from explaining mathematical ideas to classmates, discussing alternative solution strategies, and receiving immediate peer feedback. Nevertheless, the effectiveness of cooperative learning was strongly influenced by group composition, classroom management, and teacher facilitation.

Realistic Mathematics Education emphasized connecting mathematical concepts with meaningful real-life contexts. The reviewed studies consistently reported positive outcomes in students' conceptual understanding and mathematical literacy when instruction incorporated authentic situations familiar to learners. Contextualized mathematical activities enabled students to recognize the relevance of mathematics in everyday life while supporting gradual abstraction from concrete experiences to formal mathematical reasoning.

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Technology-enhanced mathematics teaching represented one of the fastest-growing research themes during the review period. Digital learning platforms, dynamic mathematics software, virtual manipulatives, online collaborative environments, and artificial intelligence-supported instructional systems were increasingly integrated into classroom practice. The reviewed studies indicated that technology enhanced visualization, interactive learning, formative assessment, and student engagement. Nevertheless, successful implementation depended on technological infrastructure, teachers' digital competence, and equitable access to learning resources.

Across the reviewed literature, several recurring factors influenced the effectiveness of mathematics teaching methods. Teacher pedagogical knowledge, classroom management, instructional design, curriculum alignment, assessment practices, students' prior mathematical knowledge, and institutional support consistently emerged as critical determinants of successful implementation. Consequently, no single teaching method could be regarded as universally superior across all educational contexts. Instead, instructional effectiveness depended largely on the interaction between pedagogical approach, learner characteristics, mathematical content, and educational environment.

The findings of this review indicate that contemporary mathematics education increasingly favors learner-centered instructional approaches that encourage active participation, collaboration, inquiry, and authentic problem solving. Compared with conventional teacher-centered instruction, these approaches generally demonstrated stronger potential for improving conceptual understanding, mathematical reasoning, problem-solving ability, communication, and learning motivation. However, the reviewed literature also suggests that effective implementation requires careful planning, continuous professional development for teachers, and adequate educational resources.

Overall, the synthesis highlights the continuing transformation of mathematics education toward more interactive, contextual, and technology-supported instructional practices. Future research should focus on conducting longitudinal investigations, comparing multiple instructional approaches across diverse educational settings, and examining the long-term impact of emerging technologies, including artificial intelligence, adaptive learning systems, and learning analytics, on mathematics teaching and learning.

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CONCLUSION

This systematic literature review synthesized empirical evidence on mathematics teaching methods implemented in primary and secondary education between January 2015 and December 2025 using the PRISMA 2020 framework. The findings indicate a significant shift from traditional teacher-centered instruction toward learner-centered pedagogical approaches that actively engage students in meaningful mathematical learning. Instructional methods such as Problem-Based Learning, Project-Based Learning, Inquiry-Based Learning, Discovery Learning, Cooperative Learning, Realistic Mathematics Education, Flipped Classroom, and technology-enhanced learning consistently demonstrated positive contributions to students' conceptual understanding, mathematical reasoning, problem-solving skills, critical thinking, communication, learning motivation, and classroom engagement. Nevertheless, the review also shows that the effectiveness of these teaching methods depends on contextual factors, including teachers' pedagogical competence, curriculum implementation, instructional design, students' prior knowledge, classroom characteristics, and the availability of technological resources. These findings emphasize that no single instructional method is universally effective, and mathematics teachers should adopt flexible, evidence-informed pedagogical strategies that are aligned with learning objectives and students' educational needs.

This review contributes to the field of mathematics education by providing a comprehensive synthesis of recent empirical research, identifying major instructional trends, and highlighting effective teaching practices that can inform educational policy, curriculum development, and classroom instruction. At the same time, the review identifies important research gaps, particularly the limited availability of longitudinal studies, comparative cross-national investigations, and research examining the long-term impact of emerging technologies such as artificial intelligence, adaptive learning systems, and learning analytics on mathematics learning. Future research should therefore focus on evaluating the sustainability, scalability, and contextual effectiveness of innovative mathematics teaching methods across diverse educational settings. Such efforts will strengthen the evidence base for mathematics education and support the development of instructional practices that enhance students' mathematical competencies and prepare them for the challenges of an increasingly technology-driven and knowledge-based society.

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