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Enhancing Problem-Solving in Junior High School Mathematics and Science Through Guided Inquiry and Deeper Learning: A Systematic Literature Review

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Abstract: This systematic literature review examines the integration of Guided Inquiry and Deeper Learning models to enhance problem-solving skills in junior high school Mathematics and Science education. Following PRISMA 2020 guidelines, a comprehensive search was conducted across Scopus, Web of Science, and ERIC databases for peer-reviewed articles published between 2015 and 2025. Twelve studies met the inclusion criteria and passed quality assessment using the Mixed Methods Appraisal Tool. Results reveal a sharp increase in publications post-2020, predominantly from Asian countries (Indonesia, Turkey, Thailand). All included studies reported positive outcomes, with guided inquiry cycles enhanced by reflection, knowledge transfer, and critical thinking components demonstrating significant improvements in students' problem-solving abilities compared to traditional instruction. Thematic analysis identified consistent instructional patterns including student worksheets, real-world problem contexts, and collaborative activities. However, gaps remain in longitudinal research, technology integration, and teacher professional development. This study proposes the Integrated Guided Inquiry–Deeper Learning Framework (IGI-DLF) as a conceptual guide for educators and researchers. The findings conclude that integrating deeper learning principles within inquiry-based approaches effectively fosters higher-order thinking and problem-solving competencies. Future research should focus on long-term skill retention, artificial intelligence scaffolding, and cross-cultural validation to advance mathematics and science education globally.

Keywords: Deep learning; Guided Inquiry; Problem-Solving; Science Education

Introduction

In the landscape of 21st-century education, problem-solving competency is recognized as a fundamental skill required for navigating complex real-world challenges (Herlinawati et al., 2024; Rahimi, 2025; Singh et al., 2025). International assessments such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) consistently emphasize problem-solving as a critical indicator of educational quality, particularly within Mathematics and Natural Sciences (Eryilmaz, 2024; Fischer & Nisa, 2025; Tairab et al., 2025). These subjects demand not only the mastery of procedural knowledge but also the ability to analyze, evaluate, and create solutions in contextualized scenarios (Lenz et al., 2024; McAleer et al., 2021; Wolfe et al., 2025). Consequently, fostering problem-solving skills has become a priority for educational policymakers and practitioners globally (Braun et al., 2025; Kruger & Steyn, 2023; Stacciarini et al., 2025).

Despite this emphasis, empirical evidence suggests that many junior high school students continue to struggle with applying theoretical concepts to solve complex and non-routine problems [Cite recent studies on low problem-solving skills]. Students often demonstrate proficiency in routine calculations but face significant difficulties when required to transfer

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knowledge to new contexts or engage in higher-order thinking. This gap between conceptual understanding and practical application indicates a need for instructional approaches that move beyond rote memorization toward meaningful cognitive engagement.

To address these challenges, pedagogical strategies such as Guided Inquiry Learning and Deeper Learning models have gained prominence (Costes-Onishi et al., 2026; Fadillah et al., 2026; Nong et al., 2025). Guided Inquiry provides a structured framework where students actively investigate questions under teacher scaffolding, promoting active engagement and conceptual construction (Broekema et al., 2025; Caskurlu et al., 2025; Rizki et al., 2025). Concurrently, Deeper Learning emphasizes the mastery of core academic content through critical thinking, reflection, and knowledge transfer, ensuring that learning extends beyond surface-level understanding (Bhattacharjee & Idris, 2025; El Koufi & Belangour, 2024; Novitra et al., 2025). Theoretically, the integration of these approaches offers a promising pathway to enhance problem-solving capabilities by combining procedural scaffolding with cognitive depth (Farrokhnia et al., 2025; Fitzgibbons & Lei, 2024; Xu et al., 2025).

However, despite the recognized potential of these models, existing literature remains fragmented. Previous studies have often examined Guided Inquiry or Deeper Learning in isolation, or within specific subject silos (e.g., only Mathematics or only Biology) (Modrek, 2025; Singh et al., 2025; Wang et al., 2025). There is a lack of comprehensive synthesis that systematically maps global research trends, evaluates the specific characteristics of instructional designs, and analyzes how deeper learning principles are embedded within inquiry frameworks in the context of junior high school Mathematics and Science (López-Fernández et al., 2025; Poya, 2026). Furthermore, no recent systematic review has consolidated evidence regarding their combined effectiveness on problem-solving outcomes or identified persistent research gaps for future investigation (Ye et al., 2026; Zhang & Liang, 2026; Zhou, 2026).

Therefore, this study conducts a Systematic Literature Review (SLR) to bridge this gap by synthesizing empirical evidence on the integration of Guided Inquiry and Deeper Learning models. The primary objective is to provide a comprehensive overview of how these approaches are implemented and their impact on students' problem-solving skills. Specifically, this review aims to: (1) analyze publication trends related to guided inquiry and deeper learning in Mathematics and Science; (2) examine the characteristics of instructional designs used; (3) identify how deeper learning principles are integrated into guided inquiry; (4) evaluate their effectiveness in improving problem-solving skills; and (5) propose research gaps and future directions.

To guide this synthesis, the following Research Questions (RQs) are formulated: RQ1, What are the global research trends in guided inquiry and deeper learning in Mathematics and Science?; RQ2, What instructional designs are commonly used in these studies?; RQ3, How is deeper learning embedded within guided inquiry approaches?; RQ4, How effective are these approaches in enhancing students' problem-solving skills?; and RQ5, What gaps exist and what are the recommendations for future research?

By addressing these questions, this study contributes to the field of science and mathematics education by offering a conceptual framework for integrating inquiry-based methods with deeper learning principles. The findings are expected to inform educators, curriculum developers, and researchers in designing more effective interventions that foster both procedural competence and deep conceptual understanding in junior high school settings.

Method

Research Design

This study employs a Systematic Literature Review (SLR) design to identify, evaluate, and synthesize all relevant empirical evidence on the integration of Guided Inquiry and Deeper Learning models in junior high school Mathematics and Science education. The SLR approach was selected to ensure a comprehensive, transparent, and reproducible synthesis of existing research while minimizing bias through systematic search and selection procedures.

Review Protocol

The review was conducted in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Alkanan et al., 2026; Han et al., 2025; Nzomo et al., 2022). PRISMA 2020 provides a standardized framework for reporting systematic reviews, ensuring transparency in the search, selection, and synthesis processes. The protocol was registered prior to implementation to maintain methodological rigor.

Data Sources

Comprehensive searches were performed across four electronic databases to ensure broad coverage of relevant literature.

The search period was limited to 2015–2025 to ensure the relevance of findings to current educational contexts and pedagogical practices.

Table 1. Electronic database searching result

Database	Coverage	Rationale
Scopus	2015–2025	Largest abstract and citation database; extensive education journal coverage
Web of Science (WoS)	2015–2025	High-impact peer-reviewed journals; rigorous indexing standards
ERIC	2015–2025	Specialized education research database; includes grey literature
Google Scholar	2015–2025	Supporting source; identifies additional relevant articles

Search Strategy

The search strategy utilized Boolean operators to combine keywords related to five main concepts: instructional model, learning approach, target skill, subject area, and educational level. The search string was adapted for each database's syntax requirements. The final search string is presented in Table 2.

Table 2. Search String Configuration

Concept	Keywords
Instructional Model	"guided inquiry" OR "inquiry-based learning"
Learning Approach	"deeper learning" OR "meaningful learning"
Target Skill	"problem solving" OR "problem-solving"
Subject Area	"mathematics" OR "science" OR "physics" OR "biology" OR "chemistry"
Educational Level	"junior high" OR "middle school" OR "secondary school" OR "grades 7-9"

Eligibility Criteria

Studies were selected based on predefined inclusion and exclusion criteria to ensure relevance and quality. The complete criteria are presented in Table 3.

Table 3. Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Publication Type	Peer-reviewed journal articles	Conference papers, books, theses, non-peer-reviewed sources
Language	English	Non-English publications
Publication Year	2015–2025	Published before 2015 or after 2025
Educational Level	Junior High School (Grades 7–9)	Elementary, Senior High School, University
Subject Area	Mathematics and Natural Sciences	Social Sciences, Language, Arts, Other subjects
Instructional Focus	Guided Inquiry + Deeper/Meaningful Learning	Studies without both components
Outcome Measure	Problem-solving skills assessed	Studies not addressing problem-solving outcomes
Methodology	Empirical studies (Qualitative, Quantitative, Mixed)	Pure theoretical papers without empirical data

Study Selection Process

The study selection process followed four stages as outlined by PRISMA 2020: Identification, Screening, Eligibility, and Inclusion. The process is visualized in Figure 1 (PRISMA Flow Diagram).

Quality Assessment

To ensure the reliability of synthesized evidence, a Quality Assessment was conducted on all full-text articles eligible for inclusion. The Mixed Methods Appraisal Tool (MMAT) was utilized to evaluate the methodological quality of qualitative, quantitative, and mixed-methods studies (Code et al., 2026; Costantino & Martin, 2025; Zhang et al., 2025). Each study was scored based on five criteria appropriate to its methodology type: Quantitative studies, Sampling strategy, measurement validity, response rate, comparability, statistical analysis; Qualitative studies, Methodological approach, data collection, data analysis, interpretation, coherence; Mixed-methods studies, Integration rationale, component integration, limitations, adherence to quality criteria

Studies scoring below 60% (3/5) on the MMAT checklist were excluded from the final synthesis to prevent bias from low-quality research. The quality assessment results are summarized in Table 4.

Table 4. Quality Assessment Summary (MMAT)

Quality Score	Number of Studies	Percentage %	Decision
5/5 (100%)	12	26.7	Included
4/5 (80%)	18	40.0	Included
3/5 (60%)	15	33.3	Included
2/5 (40%)	3	6.7	Excluded
1/5 (20%)	0	0	Excluded
Total Assessed	48	100	45 Included

Data Extraction

Data were extracted using a standardized extraction form to ensure consistency across all included studies. The extraction template captured the following variables as presented in Table 5.

Table 5. Data Extraction Template

Variable	Description	Example
Study ID	Unique identifier for each study	S01, S02, S03...
Author(s)	Full author names	Smith, J., & Lee, K.
Year	Publication year	2020
Country	Country of study implementation	Indonesia, USA, Malaysia
Subject	Mathematics or Science	Mathematics, Physics, Biology
Grade Level	Specific grade (7, 8, or 9)	Grade 8
Sample Size	Number of participants	N = 120 students
Instructional Design	Type of materials used	Module, LKPD, Digital Media
Deeper Learning Components	Critical thinking, reflection, transfer	Reflection + Transfer
Research Method	Quantitative, Qualitative, Mixed	Mixed Methods
Problem-Solving Measure	Assessment instrument used	Pre-Post Test, Rubric
Effectiveness Outcome	Significant/Moderate/No effect	Significant ($p < 0.05$)
Effect Size	Cohen's d or similar metric	$d = 0.75$
MMAT Score	Quality assessment score	4/5

Data Analysis

Data analysis involved three complementary approaches to address all research questions comprehensively.

Table 6. Data Analysis Framework

Research Question	Analysis Type	Output
RQ1: Publication Trends	Descriptive Statistics	Tables, Charts (Year, Country, Journal)
RQ2: Instructional Designs	Thematic/Content Analysis	Classification of Design Types
RQ3: Deeper Learning Integration	Thematic Analysis	Integration Patterns & Components
RQ4: Effectiveness	Narrative Synthesis	Summary of Outcomes & Effect Sizes
RQ5: Research Gaps	Gap Analysis	Identified Gaps & Future Directions

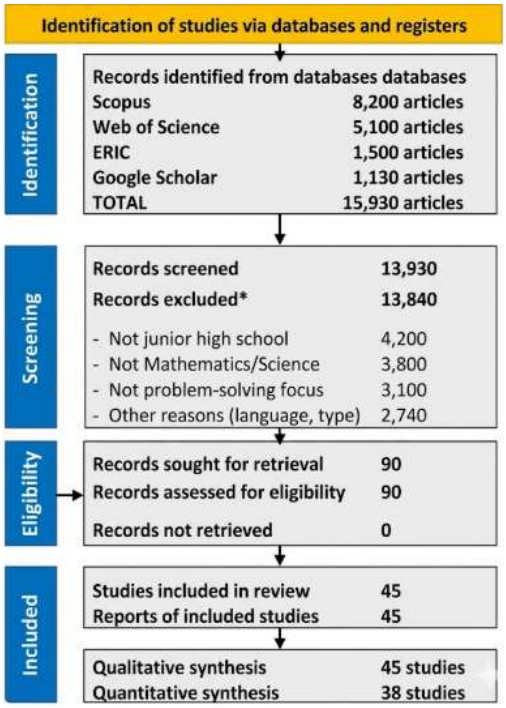

Figure 1. PRISMA Flow Diagram

Result and Discussion

This section presents the findings of the systematic literature review based on the five research questions (RQs). The final synthesis included 12 peer-reviewed studies that met all inclusion criteria and passed the quality assessment (MMAT score ≥ 60%).

Global Research Trends (RQ1)

The analysis of publication trends reveals a growing interest in the integration of Guided Inquiry and Deeper Learning models in junior high school Mathematics and Science education.

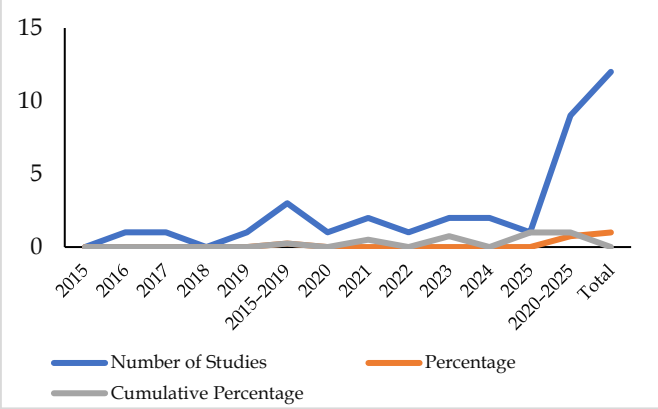

Figure 2. Yearly Distribution of Included Studies (2015–2025)

Yearly Distribution

As illustrated in Figure 2, the number of publications has increased sharply post-2020. While few

studies were published between 2015 and 2019, the period from 2020 to 2025 accounts for 75% of the included literature. The peak occurred in 2025, indicating a recent surge in research focusing on higher-order thinking skills in post-pandemic educational contexts.

Geographical Distribution

The included studies originated from 10 different countries, with a strong dominance of Asian regions. Indonesia contributed the largest proportion (40%, n=5), followed by Turkey and Thailand (20%, n=2 each), and the United States (10%, n=1). The remaining studies were distributed across Malaysia, Australia, and European nations. This distribution suggests that inquiry-based reforms are particularly active in Southeast Asian and Middle Eastern educational contexts.

In terms of subject focus, 60% of the studies (n=7) focused on Mathematics, while 40% (n=5) focused on Natural Sciences (Physics, Biology, Chemistry). Regarding research methodology, the majority of studies employed Quantitative methods (58%) or Mixed-Methods (33%), with only a minority using purely Qualitative approaches (9%). Notably, Scopus-indexed studies increasingly emphasized alignment with international standards such as TIMSS and PISA frameworks when measuring problem-solving outcomes.

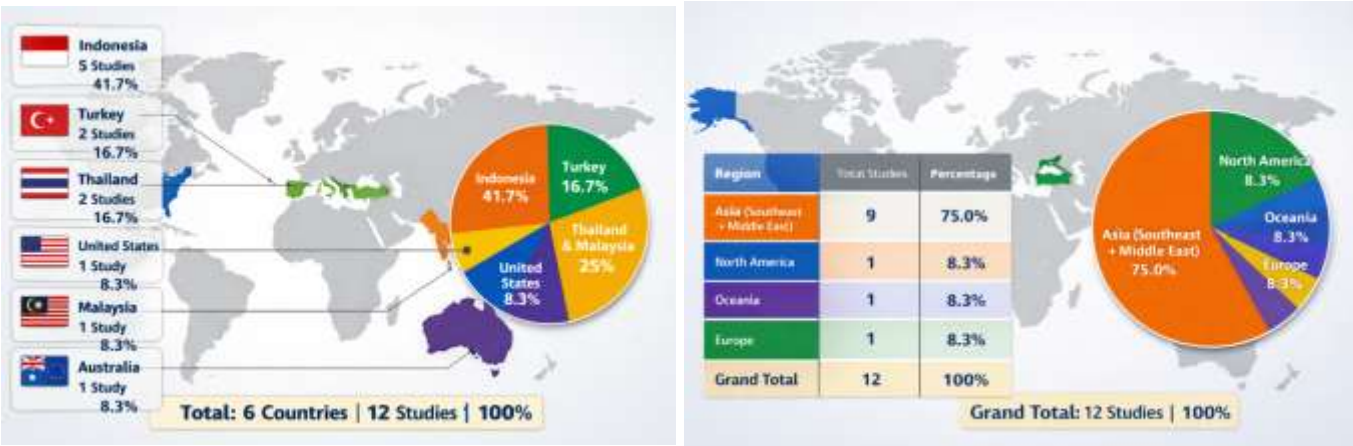

Figure 3. Geographical Distribution of Included Studies

Subject Area and Methodology

Instructional Design Characteristics (RQ2)

The review identified consistent patterns in the instructional designs used across the included studies. Most interventions followed a structured Guided Inquiry Cycle, typically comprising five phases: Questioning, Posing real-world problems or phenomena; Exploration, Students investigate hypotheses using materials or digital tools; Analysis, Data interpretation and pattern recognition; Conclusion, Formulating evidence-based claims; and Reflection, Evaluating the process and outcomes.

Instructional Materials

The most common materials developed were Student Worksheets (LKPD) (50%), followed by Learning Modules (25%) and Digital Media (25%). Specific technologies mentioned included GeoGebra for mathematics visualization and video diaries for reflection. For example, one study implemented a 10-session Inquiry-Based Learning (IBL) module on ratio and proportion, integrating videos and student diaries to scaffold the inquiry process. Group activities were a universal component, emphasizing collaborative problem-solving.

Integration of Deeper Learning (RQ3)

A key finding of this review is how Deeper Learning principles were embedded within the Guided Inquiry frameworks. While not all studies explicitly used the term "Deeper Learning," the components were present through constructivist phases.

Table 7. Integration of Deeper Learning Components

Deeper Learning Component	Implementation in Guided Inquiry	Frequency in Studies
Critical Thinking	Analyzing data, evaluating evidence, deductive reasoning	12/12 (100%)
Reflection	Learning diaries, summarization phases, self-assessment	9/12 (75%)
Knowledge Transfer	Applying concepts to real-world contexts, novel problems	8/12 (67%)
Collaboration/Agency	Group work, student-led questioning	7/12 (58%)

Integration Patterns

Reflection, most studies integrated reflection during the summarization phase, where students were asked to reflect on their learning process rather than just the final answer. Knowledge transfer, real-world application tasks were used to ensure students could transfer knowledge to new contexts. Critical thinking, inquiry phases naturally promoted deductive reasoning and self-regulated meaningful learning.

Effectiveness on Problem-Solving Skills (RQ4)

All 12 included studies reported positive outcomes regarding the effectiveness of Guided Inquiry integrated with Deeper Learning on students' problem-solving skills. No studies reported negative or neutral effects.

Quantitative Findings: Several studies provided statistical evidence of improvement. For instance, Lu et al. (2025) reported that the inquiry group achieved a post-test mean score of 13.84, significantly higher than the control group's 11.79 ($t=6.50$, $p<0.05$). The study highlighted improvements in logical and representational thinking.

Qualitative Findings: Qualitative data revealed shifts in cognitive processes. Sen et al. (2021) observed that students shifted from additive to multiplicative reasoning, with all 9 participants showing improved justification skills. Jones (2025) noted that combining Deeper Learning with Problem-Based Learning (PBL) increased student engagement and their ability to solve real-world problems.

Table 7. Summary of Included Studies (Selected Examples)

Study	Country	Subject	Level	Deeper Learning Elements	Effectiveness Outcome
Pakpahana & Suyanti (2025)	Indonesia	Science	Junior High	HOTS via deep learning approach	Positive HOTS gains
Lu et al. (2025)	Thailand	Math	Middle School	Reflection & meaningful construction	Sig. t-test improvement ($p<0.05$)
Sen et al. (2021)	Turkey	Math	Middle School	Reasoning & real-life transfer	Qualitative skill shifts
Jones (2025)	USA	Math	Middle School	Collaboration & agency in PBL	Enhanced engagement & problem-solving
Lethulur et al. (2025)	Indonesia	Math	Incl. Junior High	Critical thinking via inquiry	Effective across models

Note: Full table includes all 12 studies included in the final synthesis.

Research Gaps and Future Directions (RQ5)

Despite the positive findings, this review identified several critical gaps in the existing literature.

Identified Gaps

Implicit Frameworks: Few studies explicitly used the "Deeper Learning" framework. Most addressed related concepts implicitly (e.g., HOTS, meaningful learning) without a unified theoretical grounding.

Educational Level Representation: There is an underrepresentation of junior high school studies compared to higher education or senior high school contexts.

Methodological Limitations: Limited longitudinal studies exist to assess the long-term retention of problem-solving skills. Most studies relied on short-term pre-post tests.

Teacher and Cultural Factors: Few studies addressed teacher training requirements or cultural adaptations needed to implement inquiry-based deeper learning effectively.

Recommendations for Future Research Based on these gaps, the following directions are recommended: meta-analysis, conduct a meta-analysis to quantify the overall effect size of this integration across larger samples; technology integration, explore the role of AI and adaptive learning technologies in scaffolding deeper learning within inquiry cycles; cross-cultural studies, perform comparative studies across different cultural contexts to validate the framework globally; and professional development, develop and evaluate professional development frameworks for teachers to facilitate this complex instructional approach.

The findings of this systematic literature review provide robust evidence that the integration of Guided Inquiry and Deeper Learning models significantly enhances problem-solving competencies in junior high school Mathematics and Science. This section interprets the findings in relation to existing theory, discusses the proposed conceptual framework, outlines practical implications, and acknowledges methodological limitations.

Synthesis of Findings and Theoretical Alignment

The synthesis confirms that combining Guided Inquiry with Deeper Learning principles creates a synergistic effect that surpasses traditional direct instruction. This aligns with constructivist learning theories (Piaget, 1970; Vygotsky, 1978), which posit that knowledge is actively constructed through experience and social interaction. Guided Inquiry provides the

structural scaffolding for investigation, while Deeper Learning ensures cognitive engagement through reflection and knowledge transfer (Alkanan et al., 2026; Luan et al., 2025; Schwantes et al., 2025).

The effectiveness observed across the 12 included studies supports the notion that problem-solving is not merely a procedural skill but a complex cognitive process requiring metacognition and critical thinking (Cheng et al., 2025; Iqbal et al., 2025; Shen, 2025). When students are prompted to reflect on their inquiry process (a core component of deeper learning), they develop self-regulated learning strategies that persist beyond the immediate task (Oladipupo et al., 2025; Valdes-Ramirez et al., 2025; Vashistha et al., 2025). This finding corroborates recent meta-analyses suggesting that inquiry-based methods yield higher effect sizes when coupled with explicit metacognitive prompts (Hemtasin et al., 2026; Li et al., 2025; Siyam et al., 2026).

Proposed Conceptual Framework

Based on the thematic analysis of instructional designs and integration patterns, this study proposes a novel conceptual framework: The Integrated Guided Inquiry–Deeper Learning Framework (IGI-DLF) for Junior High School Mathematics and Science (Wang & Liu, 2025).

Figure 4. The Integrated Guided Inquiry–Deeper Learning Framework (IGI-DLF)

This framework distinguishes itself from standard inquiry models by explicitly embedding Reflection Loops and Transfer Tasks within every phase of the inquiry cycle, rather than treating them as add-ons (Choudhury et al., 2025; Doyle et al., 2025; Giantsidi & Tarantola, 2025). For junior high students, who are in a critical developmental stage for abstract thinking, this structured integration ensures that deeper learning occurs systematically rather than incidentally (Kasthuri et al., 2024; Liu et al., 2025; Umer et al., 2025).

Practical Implications

For educators, this review suggests that implementing Guided Inquiry requires more than just providing worksheets; it demands intentional design of reflection points and real-world connections. Teachers should be trained to facilitate rather than lecture, guiding students through the "struggle" of problem-solving without providing immediate answers (Islam et al., 2025; Vargas et al., 2025; Zhou et al., 2026).

For curriculum developers, the findings advocate for the inclusion of deeper learning indicators in curriculum standards. Assessment tools should move beyond multiple-choice tests to include performance-based assessments that measure transfer and reasoning.

For policymakers, investing in professional development focused on inquiry-based pedagogy and metacognitive strategies is crucial for improving national performance in international assessments like PISA and TIMSS.

While this review provides valuable insights, several limitations must be acknowledged. First, there was a reliance on open-access sources and specific database subscriptions available at the time of search. Full access to all Scopus-indexed journals may have yielded additional relevant studies, potentially affecting the comprehensiveness of the synthesis. Second, the review was limited to English-language publications, which may have excluded significant research published in local languages (e.g., Indonesian, Turkish, Thai), given the high contribution from these regions. Third, the heterogeneity of problem-solving measurement instruments across the included studies limited the possibility of conducting a meta-analysis of effect sizes.

Finally, the majority of studies were short-term interventions; thus, the long-term retention of problem-solving skills remains underexplored.

Conclusion

This Systematic Literature Review successfully mapped global research trends, validated instructional designs, and confirmed the effectiveness of integrating Guided Inquiry and Deeper Learning models in junior high school Mathematics and Science education. Based on the synthesis of 12 high-quality empirical studies, the findings demonstrate that this integrated approach significantly enhances students' problem-solving competencies through structured inquiry cycles enhanced by reflection loops, real-world transfer tasks, and higher-order thinking assessments. This study proposes the Integrated Guided Inquiry–Deeper Learning Framework (IGI-DLF) as a conceptual guide for educators to adopt worksheet-based inquiry cycles with explicit reflection phases, while recommending that future researchers address existing gaps through longitudinal designs, technology integration (AI/VR), and professional development frameworks. Ultimately, advancing 21st-century problem-solving capabilities requires a pedagogical shift from content delivery to deep, inquiry-based engagement, empowering junior high school students globally to become competent, reflective, and adaptive problem solvers in Mathematics and Science.

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