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Integrating Indonesian Realistic Mathematics Education (PMRI) and STEM Approaches in High School Students: A Systematic Literature Review

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ABSTRAK

Penelitian ini menyajikan Systematic Literature Review (SLR) mengenai integrasi pendekatan Indonesian Realistic Mathematics Education (PMRI) dan STEM dalam pembelajaran matematika. Kajian ini bertujuan memetakan tren penelitian, konteks pembelajaran, konten matematika, kompetensi yang dikembangkan, serta temuan utama studi periode 2015–2025. Proses telaah dilakukan melalui identifikasi, penyaringan berbasis kriteria inklusi dan eksklusi yang jelas, serta sintesis tematik terhadap artikel dari basis data ilmiah bereputasi. Dari seluruh artikel yang teridentifikasi, 15 studi lolos seleksi ketat dan dianalisis mendalam. Hasil kajian menunjukkan integrasi PMRI–STEM diwujudkan melalui masalah kontekstual dunia nyata yang dipadukan dengan aktivitas investigatif, pemodelan matematis, dan proyek berbasis desain. Pendekatan ini diterapkan pada berbagai topik, termasuk geometri, pengukuran, aljabar, trigonometri, dan numerasi. Temuan studi menunjukkan kontribusi positif terhadap pemahaman konsep, pemecahan masalah, literasi matematika, berpikir kreatif, serta keterampilan berpikir tingkat tinggi. Selain berdampak pada siswa, beberapa penelitian melaporkan peningkatan kompetensi guru dalam merancang pembelajaran berbasis teknologi. Berbeda dari SLR sebelumnya yang membahas PMRI atau STEM secara terpisah, kajian ini secara khusus menelaah integrasi pedagogis keduanya dalam pembelajaran matematika. Kajian ini menyimpulkan bahwa integrasi PMRI–STEM berpotensi sebagai kerangka pembelajaran inovatif dan interdisipliner abad ke-21, dengan rekomendasi pengembangan desain yang lebih sistematis dan implementasi lintas jenjang.

Kata kunci: PMRI, STEM, pembelajaran matematika, systematic literature review

ABSTRACT

This study presents a Systematic Literature Review (SLR) on the integration of the Indonesian Realistic Mathematics Education (PMRI) and STEM approaches in mathematics learning. The review aims to map research trends, learning contexts, mathematical content, developed competencies, and key findings of studies published between 2015 and 2025. The review process involved identification, screening based on explicit inclusion and exclusion criteria, and thematic synthesis of articles obtained from reputable academic databases. Out of all identified articles, 15 studies passed a rigorous selection process and were analyzed in depth. The findings indicate that PMRI–STEM integration is commonly implemented through real-world contextual problems combined with investigative activities, mathematical modeling, and design-based projects. This approach has been applied across various topics, including geometry, measurement, algebra, trigonometry, and numeracy. The reviewed studies report

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positive contributions to conceptual understanding, problem-solving skills, mathematical literacy, creative thinking, and other higher-order thinking skills. In addition to its impact on students, several studies also highlight improvements in teachers' competence in designing technology-supported contextual learning. Unlike previous reviews that examined PMRI or STEM separately, this study specifically focuses on their pedagogical integration in mathematics education. The review concludes that PMRI–STEM integration holds strong potential as an innovative and interdisciplinary framework aligned with 21st-century learning demands and recommends more systematic instructional designs and broader implementation across educational levels.

Keywords: PMRI, STEM education, mathematics learning, systematic literature review

INTRODUCTION

In the context of 21st-century education, developing strong mathematical competence alongside meaningful, contextual learning has become a central concern in both research and practice in mathematics education (Maqruf et al., 2025). One approach that addresses this demand is Indonesian Realistic Mathematics Education (PMRI), a localized adaptation of Realistic Mathematics Education (RME) that situates real-world contexts as the starting point of instruction. Through this approach, students are guided to construct mathematical understanding progressively from authentic situations toward more formal concepts (Putri et al., 2025; Sari, Zulkardi, et al., 2025; Zulkardi & Putri, 2019). Empirical evidence indicates that PMRI contributes positively to students' conceptual understanding, mathematical literacy, and problem-solving skills (Fitriyana et al., 2023; Mufti et al., 2023).

Responding to similar 21st-century challenges, the STEM (Science, Technology, Engineering, and Mathematics) approach has also gained global recognition as a framework that connects mathematics with interdisciplinary knowledge and real-world problem solving. STEM-based learning not only strengthens conceptual links between disciplines but also promotes higher-order thinking skills such as problem solving, creativity, and collaboration (Rachmawati & Juandi, 2023). Recent literature reviews show that STEM integration in mathematics education is commonly implemented through project-based and design-oriented learning environments, enabling students to apply mathematical ideas in authentic contexts (Agus et al., 2025).

Although both PMRI and STEM emphasize contextual learning and the development of higher-order thinking, their integration in mathematics education has not yet been systematically mapped. Existing studies tend to examine PMRI or STEM independently, while research explicitly exploring their combined use in instructional design remains limited. For instance, Sari et al., (2025) implemented PMRI through an agricultural context primarily to support students' conceptual understanding of ratios, whereas Raivo & Ardiansyah (2024) applied STEM-based Challenge-Based Learning mainly to enhance creative thinking skills. Conceptually, PMRI offers a strong foundation for meaningful learning through contextualization and guided reinvention, while STEM enriches instruction through interdisciplinary integration and design-based practices.

This situation underscores the need for a comprehensive review to understand how PMRI and STEM are integrated in mathematics learning, how such integration is

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designed and implemented, and how it contributes to students' mathematical outcomes. Therefore, this study conducts a Systematic Literature Review (SLR) to map research trends, instructional design characteristics, mathematical topics and contexts, and the impact of PMRI–STEM integration on students' mathematical abilities. The findings are expected to provide both theoretical and practical foundations for developing innovative, contextual, and 21st-century-relevant mathematics learning models.

METHOD

This study employed a Systematic Literature Review (SLR) to synthesize research on PMRI and STEM in mathematics education. The review followed three stages: planning, conducting, and reporting (Xiao & Watson, 2019; Sari et al., 2025). In this review, the participants were not individuals but published empirical studies that investigated the integration of PMRI and STEM in mathematics learning. During the planning stage, research questions were formulated to explore trends in PMRI–STEM studies published between 2015 and 2025, focusing on research topics, learning contexts, mathematical content, targeted competencies, and reported findings. A review protocol was developed using the keywords "PMRI" and "STEM", with Scopus and Google Scholar serving as the primary databases. Article identification was supported by the Publish or Perish tool.

In the conducting stage, the search initially yielded 101 records. After removing 2 books, the remaining articles were screened based on titles and abstracts, resulting in the exclusion of 75 articles due to irrelevance, incomplete information, or lack of accessibility. A full-text assessment of the remaining studies led to the exclusion of 9 additional articles that did not meet the eligibility criteria. Ultimately, 15 peer-reviewed journal articles were selected through this rigorous screening process. Table 1 contains the inclusion and exclusion criteria used in this research.

Table 1. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication Type	Journal articles	Books, theses, conference abstracts, non-peer-reviewed sources
Time Range	Published between 2015–2025	Published before 2015
Research Focus	Studies explicitly integrating PMRI or STEM in mathematics education	Studies not discussing about PMRI or STEM separately without integration
Educational Field	Mathematics education	Studies outside mathematics education
Accessibility	Full text accessible	Incomplete or inaccessible full text
Content Relevance	Reports instructional design, implementation, or learning outcomes	Purely theoretical papers without classroom or learning context

In the reporting stage, the selected studies were analyzed thematically based on research focus, instructional design characteristics, learning contexts, mathematical

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topics, targeted competencies, and key findings. The entire selection procedure was conducted systematically and transparently, as illustrated in Figure 1.

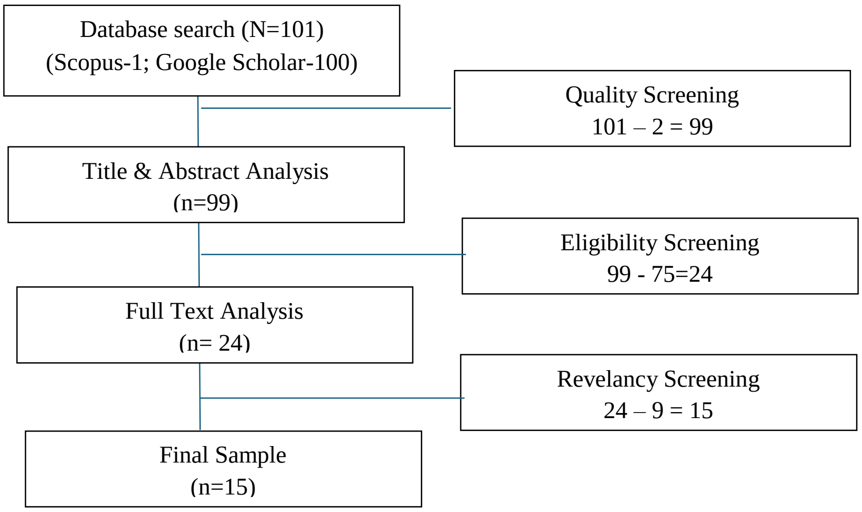

Figure 1. Article selection process

RESULT AND DISCUSSION

Result in the planning stage, the review focused on how studies published between 2015 and 2025 address research content, learning contexts, targeted competencies, and key findings related to PMRI and STEM integration. Result in conducting stage, articles were systematically identified, screened, and selected based on predefined inclusion criteria, resulting in 15 eligible studies. In the reporting stage, data from these studies were analyzed and synthesized, including descriptions of research content, learning contexts, targeted competencies, and principal findings concerning the implementation of PMRI and STEM in mathematics learning. The synthesis of these findings is systematically presented in Table 2.

Table 2. Summary of literature review findings on PMRI and STEM (2015–2025)

No	Researcher and Year	Content	Context	Competency	Findings
1	(Albab et al., 2025)	Geometry – Volume of Three-Dimensional Shapes	design bakpia carton	Understanding concept	A learning design that engages students in informally calculating volume through repeated and layered filling activities has been shown to build conceptual understanding and deepen students' awareness of volume as the amount of space occupied.
2	(Mariani et al., 2025)	PISA and AKM	STEM-PMRI Learning and	Mathematics Literacy	LMS-assisted STEM-PMRI training improves teachers' ability to integrate real-world contexts in accordance

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No	Researcher and Year	Content	Context	Competency	Findings
			Learning Management System Applications		with PISA standards, which has a positive impact on learning readiness to improve students' mathematical literacy in facing AKM.
3	(Wati & Ramadianti, 2025)	geometry, measurement, and symmetry	kite-making activities	Mathematical Logical Thinking Skills	The study found that STEM-based, project-driven kite-making activities effectively enhanced students' mathematical and logical thinking by helping them apply geometry and measurement concepts in practical tasks while developing systematic reasoning, argumentation, and problem-solving skills.
4	(Efriani & Arifin, 2025)	Cube	STEM Learning assisted by Artificial Intelligence	Understanding concept	STEM learning trajectory assisted by Artificial Intelligence (AI) which contained the following activities: exploring information, finding learning concepts, initiating ideas, and developing ideas.
5	(Efriani, 2024)	Measuring	playing balloons	Understanding concept	PMRI- and STEM-based learning design using balloon activities effectively supported early childhood students' understanding of measurement concepts through structured stages—attending to size, ordering objects by size, classifying objects, and expressing size—while integrating everyday exploration of concrete objects, with the instructional materials demonstrating high content validity

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No	Researcher and Year	Content	Context	Competency	Findings
6	(Khotimah et al., 2024)	Linear Program	E-LKPD mathematics with a STEM approach	Understanding concept	STEM-based mathematics E-LKPD developed using the ADDIE model is valid, practical, and effective for learning linear programming, as indicated by very high expert validation scores, positive student responses, and significant improvement in post-test learning outcomes compared to pre-test results
7	(Raivo & Ardiansyah, 2024)	Systems of two-variable linear equations	CBL STEM-based learning integrated with learning videos	Creative thinking ability	the CBL-STEM teaching materials integrated with instructional videos were highly feasible, easy to understand, and effective in improving students' creative thinking skills in learning systems of linear equations, as shown by strong expert validation, high readability, positive student responses, and significantly better posttest performance compared to pretest and control groups.
8	(Inayah et al., 2024)	measure of central tendency	PBL Learning with the STEAM-PMRI approach	Mathematics Literacy	learning independence has a strong positive effect on students' mathematical literacy (70% contribution) in PBL STEAM-PMRI learning, indicating that students with higher self-directed learning demonstrate better numeracy skills.
9	(Nursyahidah et al., 2023)	quadrilateral and triangle	STEM using rubber-powered car projects through lesson study	Understanding concept	The study outlined a learning trajectory comprising three STEM-based activities—designing a rubber-powered car project, analyzing properties and relationships among quadrilaterals, and solving contextual problems involving area and

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No	Researcher and Year	Content	Context	Competency	Findings
					perimeter—which enabled students to engage with the material in an active, enjoyable, and meaningful way.
10	(Efriani et al., 2023)	number content	sweet potato balls	teachers' academic and professional competencies	The study developed a STEM-based learning environment using the CAS (Campus–Application School) model that proved valid, practical, and impactful, demonstrating strong potential to enhance student teachers' academic and professional competencies as well as early mathematics learning practices.
11	(Yuliani et al., 2023)	Circles	E-LKPD STEM-based with a local wisdom theme	-	The STEM-based E-LKPD integrating local wisdom and character education for teaching circle concepts in Grade VIII is practical for classroom use, as reflected by high practicality ratings from both students and teachers.
12	(Jannah et al., 2023)	Quantity-rows and series material	STEM-Based MURDER Learning Model Assisted by Quizizz	Numeration Ability	STEM-based MURDER learning supported by Quizizz improved students' numeracy skills and achieved classical learning completeness, showing better posttest performance than before instruction and slightly outperforming PBL, although the overall effectiveness gain was categorized as low.
13	(Reksadini et al., 2022)	material for class XI in the even semester of the 2021/2022	STEM-Based CONINCON Learning	Mathematical Connection Ability	the STEM-based CONINCON learning model was of good quality and supported students' mathematical connection abilities, with higher self-confidence associated with stronger mastery of

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No	Researcher and Year	Content	Context	Competency	Findings
		academic year			mathematical connection indicators.
14	(Aprilia et al., 2021)	Linear Programming	Mathematics Learning Media Using STEM Approach	Problem-solving skills and conceptual understanding in linear programming	The STEM-based mathematics learning media developed using the Tessmer procedure was found to be highly valid, highly practical, and highly effective, indicating that it is suitable for supporting the teaching and learning of linear programming.
15	(Arivina & Jailani, 2020)	Trigonometry	The STEM-based trigonometry learning kit	problem solving skills and learning achievement	The STEM-based trigonometry learning kit was found to be valid, practical, and effective, as it improved students' problem-solving skills (high gain) and learning achievement (moderate gain) through meaningful, real-world learning activities.

The results of the Systematic Literature Review indicate that the integration of PMRI and STEM in mathematics learning is generally implemented through the use of real-world contexts that are close to students' lives, such as craft activities (Efriani et al., 2023), traditional games (Wati & Ramadianti, 2025; Efriani, 2024), daily life activities (Yuliani et al., 2023), and design-based projects (Nursyahidah et al., 2023). These contexts serve as starting points for mathematical modeling in accordance with PMRI characteristics, while also providing a medium for applying STEM principles through investigative, exploratory, and simple engineering activities.

From the perspective of mathematical content, the integration of PMRI and STEM has been widely applied to topics such as geometry (Albab et al., 2025; Yuliani et al., 2023; Wati & Ramadianti, 2025), measurement (Efriani, 2024), algebra—including linear programming and systems of linear equations in two variables (Raivo & Ardiansyah, 2024; Khotimah et al., 2024; Aprilia et al., 2021), trigonometry (Arivina & Jailani, 2020), basic statistics (Inayah et al., 2024), and numeracy (Jannah et al., 2023; Efriani et al., 2023). These findings indicate that this approach is flexible and can be implemented across various mathematical domains, particularly those that allow strong connections to contextual situations and problem-solving activities.

In terms of the competencies developed, most studies report improvements in conceptual understanding (Efriani & Arifin, 2025; Albab et al., 2025; Nursyahidah et al., 2023; Efriani, 2024), problem-solving skills (Aprilia et al., 2021; Arivina & Jailani, 2020), mathematical literacy (Mariani et al., 2025; Inayah et al., 2024), creative thinking (Raivo & Ardiansyah, 2024), logical thinking (Wati & Ramadianti, 2025), mathematical connections (Reksadini et al., 2022), and numeracy (Jannah et al., 2023).

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The PMRI approach provides a conceptual foundation through contextual modeling, while STEM enriches learning with design activities, technology integration, and project-based tasks, thereby promoting higher levels of cognitive engagement. Consequently, the integration of both approaches fosters learning that is not only conceptually meaningful but also practically applicable.

In terms of the main findings, most studies report that PMRI–STEM-based instructional tools, media, or learning designs fall into the categories of valid, practical, and effective (Khotimah et al., 2024; Yuliani et al., 2023; Aprilia et al., 2021). Learning becomes more active, enjoyable, and contextual (Efriani et al., 2023; Arivina & Jailani, 2020), and has a positive impact on both cognitive learning outcomes and higher-order thinking skills (Wati & Ramadianti, 2025; Raivo & Ardiansyah, 2024; Inayah et al., 2024). In addition, several studies highlight impacts on teachers, such as Mariani et al. (2025), which reports improvements in teachers' ability to design contextual learning based on literacy and technology.

Overall, the pattern of findings indicates that the integration of PMRI and STEM forms a complementary learning framework: PMRI emphasizes meaning making through realistic contexts and progressive modeling, while STEM highlights interdisciplinary integration, design processes, and authentic problem solving. This combination contributes to strengthening 21st-century competencies in mathematics learning.

CONCLUSION

This systematic review indicates that the integration of PMRI and STEM in mathematics education tends to support contextual, meaningful, and interdisciplinary learning, as reported in the selected studies. The approach has been implemented across a range of mathematical topics and is associated with improvements in students' conceptual understanding, problem-solving skills, mathematical literacy, and higher-order thinking skills. In addition to student outcomes, several studies also report enhancements in teachers' capacity to design innovative learning experiences grounded in real-life contexts and the use of technology. Taken together, these findings suggest that the PMRI–STEM approach represents a promising framework for mathematics learning aligned with the goals of 21st-century education. This review contributes to the literature by providing the first systematic mapping of how PMRI, as a localized adaptation of RME, is integrated with STEM approaches in mathematics education, highlighting prevailing instructional design patterns, targeted competencies, and existing research gaps.

Based on the review findings, there is a need to develop more systematic and well-documented PMRI–STEM instructional designs to enable replication across different educational levels. Future studies are recommended to investigate the implementation of PMRI–STEM integration in more diverse contexts, including schools with varying characteristics, as well as to examine its long-term effects on mathematical literacy and 21st-century competencies. Furthermore, expanding teacher professional development in designing and implementing technology-supported PMRI–STEM learning is essential to support sustainable educational innovation.

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