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Interactive Multimedia as a Catalyst for Improving Students' Mathematical Problem-Solving Ability

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ABSTRACT

Students in Indonesia often have difficulties in mathematics problem-solving, mainly due to the absence of engaging media in traditional teaching techniques. This study aimed to examine the effect of interactive learning multimedia on students' mathematical problem-solving skills. We performed a Systematic Literature Review (SLR), examining 20 papers, of which 15 were selected from accredited national journals (Sinta 1-5) sourced from Scopus and Google Scholar, with a specific emphasis on "interactive learning multimedia" and "mathematical problem-solving ability." The results repeatedly indicated that interactive learning multimedia substantially improves students' mathematical problem-solving abilities. Integrating interactive multimedia, especially within a Problem-Based Learning (PBL) framework, shown significantly greater efficacy than traditional training devoid of such media. In conclusion, interactive learning multimedia is a crucial instrument for enhancing mathematics instruction and cultivating students' critical problem-solving skills.

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Introduction

Mathematics is a compulsory subject taught at all levels of education and plays a fundamental role in the development of logical thinking, reasoning, and problem-solving skills (Chen, 2025; Atinuke & Adeneye, 2024; Salami, 2021). Beyond its position as a school subject, mathematics serves as the foundation for the advancement of science and technology and supports learning across various disciplines (Murtafiah et al., 2023; Nadhifa et al., 2019). Mastery of mathematics from an early age is therefore essential to improve the quality of human resources and to prepare students to face increasingly complex global challenges.

Despite its importance, mathematics remains one of the most challenging subjects for students (Anjariyah, et al., 2024; Kulkin, 2016). Many learners perceive mathematics as abstract and intimidating, which negatively affects their learning outcomes. International assessment results further highlight this issue. Data from PISA 2022 show that Indonesian students achieved an average mathematics score of 366, which is significantly below the average (OECD, 2023). Similarly, the results of TIMSS 2015 indicate that Indonesia consistently ranks in the lower tier compared to other participating countries (Hamzah, 2023). These findings suggest that students' mathematical abilities, particularly higher-order skills, remain relatively low and require serious pedagogical attention.

One of the major factors contributing to this condition is the limited use of innovative learning media in mathematics classrooms (Hillmayr et al., 2020); Attard, 2018; Bray & Tangney, 2017). In many learning contexts, teachers still rely heavily on textbooks and routine practice problems, resulting in teacher-centered instruction that provides minimal opportunities for students to actively construct knowledge (Kaymakamoglu, 2018; Mpho, 2018). Consequently, students tend to focus on procedural tasks rather than developing essential competencies such as mathematical problem-solving. Although several studies have examined mathematics learning outcomes in general, there is still a lack of comprehensive synthesis that specifically examines how interactive learning multimedia influences students' mathematical problem-solving abilities, which are at the core of mathematical proficiency (Purnomo et al., 2024; Hu et al., 2021). This gap indicates the need for a focused investigation that integrates evidence from existing studies.

Interactive learning multimedia is considered a promising approach to address these challenges. By integrating text, images, graphics, animations, videos, simulations, and interactive elements, multimedia learning environments can enhance student engagement and motivation (Rahma & Nyoman, 2020). Effective learning outcomes are strongly influenced by teachers' ability to design learning experiences that are both pedagogically sound and capable of stimulating students' enthusiasm (Rahmatullah, 2020). Moreover, interactive multimedia can be adapted to students' characteristics and learning needs, allowing for more personalized and meaningful learning experiences. Recent developments, such as Android-based interactive modules, offer practical and efficient learning tools that combine various digital features to support independent and active learning (Ariani et al., 2022).

Mathematical problem-solving ability is a critical skill that enables students to apply their knowledge in unfamiliar situations (Rahmawati et al., 2024). It is widely recognized as a fundamental competence that future generations must possess to face real-life and academic challenges (Daryanes et al., 2023). Problem-solving framework is understanding the problem, devising a plan, carrying out the plan, and reviewing the solution, provides a systematic foundation for developing this ability (Purba et al., 2021; Kania & Ratnawulan, 2022). Therefore, instructional strategies and media that effectively support these stages are crucial in mathematics learning.

Based on the above discussion, this study aims to systematically analyze the effect of interactive learning multimedia on students' mathematical problem-solving abilities through a literature review approach. Unlike previous studies that focus on isolated empirical findings, this research synthesizes existing evidence to identify patterns, strengths, and limitations in the use of interactive multimedia for mathematics learning (Tang et al., 2022; Noetel, et al., 2022; Verschaffel, et al., 2019). The contribution of this study lies in providing a comprehensive theoretical and empirical overview that can inform teachers, researchers, and policymakers in designing more effective, engaging, and problem-solving-oriented mathematics instruction. Ultimately, the findings are expected to serve as a foundation for

developing innovative learning media and improving the quality of mathematics education in Indonesia.

Method

This study employed a Systematic Literature Review (SLR) approach to synthesize empirical evidence on the effect of interactive learning multimedia on students' mathematical problem-solving ability. The SLR method was selected to ensure methodological rigor, transparency, and reproducibility throughout the review process (Putra & Milenia, 2021). The review protocol followed structured stages: planning, identification, screening, eligibility assessment, data extraction, and synthesis, adapted from established systematic review procedures **(Figure 1)**.

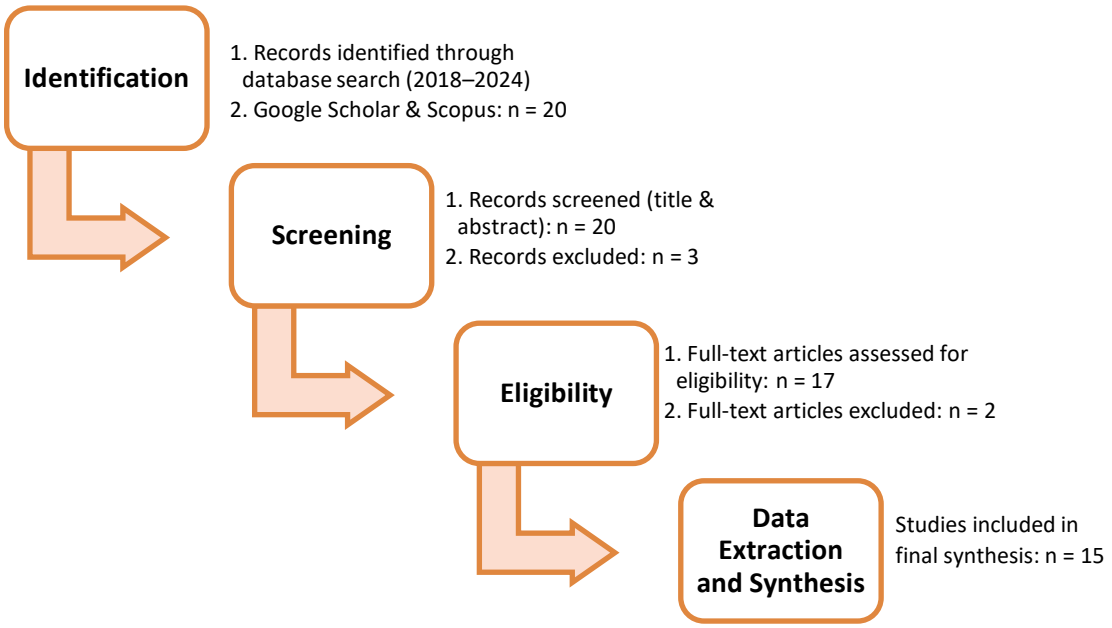

Figure 1. Research Flow Diagram of Article Selection in the Systematic Literature Review (2018–2024)

The identification stage, a comprehensive literature search was conducted using the keywords "interactive learning multimedia" and "mathematical problem-solving ability." The search was limited to peer-reviewed journal articles published between 2018 and 2024, ensuring the inclusion of recent and relevant studies that reflect current developments in educational technology. Searches were performed across Google Scholar and Scopus databases. This initial search identified 20 articles.

During the screening stage, titles and abstracts of the 20 articles were reviewed to remove duplicates and studies that were not aligned with the focus on mathematics learning or interactive multimedia. As a result, 3 articles were excluded, and 17 articles proceeded to the full-text review. In the eligibility assessment stage, full-text articles were evaluated based on predefined inclusion criteria: (1) publication in peer-reviewed journals, (2) focus on interactive multimedia in mathematics education, (3) explicit measurement or discussion of students' mathematical problem-solving ability, and (4) indexing in nationally accredited journals (Sinta 1–Sinta 5) or international databases. At this stage, 2 articles were excluded due to insufficient relevance and lack of explicit problem-solving indicators. Consequently, 15 articles were included in the final synthesis.

A data extraction sheet was developed as the primary research instrument to systematically collect key information from each selected study, including author(s), year of publication, research design, educational level, type of interactive multimedia, problem-

solving framework applied, and principal findings. The extracted data were analyzed using thematic and narrative synthesis techniques. Thematic analysis was employed to identify recurring patterns and relationships between interactive multimedia features and mathematical problem-solving processes, while narrative synthesis was used to integrate and interpret findings across studies. This approach enabled a comprehensive understanding of the pedagogical role of interactive learning multimedia and provided evidence-based insights for improving mathematics instruction.

Results and Discussion

The results of this systematic literature review are derived from 15 selected studies published between 2018 and 2024, as summarized in **Table 1**. It presents the key characteristics of the included studies, including research design, educational level, type of interactive learning multimedia, and measured problem-solving outcomes. Overall, the synthesis of these studies demonstrates a consistent positive effect of interactive multimedia on students' mathematical problem-solving abilities across different learning contexts and grade levels. This consistency indicates that interactive multimedia is not only effective in specific settings but also shows potential for broader application in mathematics education.

Table 1. Overview of Empirical Studies Examining Interactive Multimedia in Mathematics Problem Solving

No	Researcher	Research results
1	(Sari et al., 2022)	The exploration findings indicate the progress of interactive learning multimedia, enhanced with a scientific approach using Macromedia Flash, for improving understanding in solving mathematical problems.
2	(Sihombing & Fauzi, 2024)	The research findings show the development of Powtoon-based interactive multimedia through a Problem-Based Learning (PBL) model, which is both practical and effective for improving mathematical problem-solving.
3	(Hafizah & Samosir, 2023)	The research findings indicate the development of interactive learning resources based on the Canva program, which is useful and efficient for educational purposes. Students' ability to solve mathematical problems can also be improved by using the Canva program.
4	(Daryanes et al., 2023)	The results of the study show that students' problem-solving skills can be improved by the case-method-based interactive learning materials called Articulate Storyline.
5	(A. Rahmawati et al., 2024)	The results of the study demonstrate that integrating Camtasia Studio learning resources into a Problem-Based Learning (PBL) framework can help students improve their capacity for solving mathematical puzzles.
6	(Hayati et al., 2023)	The research findings analyze the improvement of students' problem-solving abilities through a Problem-Based Learning (PBL) model assisted by interactive multimedia.
7	(Maryani et al., 2022)	The research findings aim to analyze the implementation of Google Sites within a Students' problem-solving skills are assessed using the Problem-Based Learning (PBL) paradigm.
8	(Kurniawan et al., 2018)	The research findings aim to analyze the implementation of a Problem-Based Learning (PBL) model assisted by interactive multimedia to enhance students' problem-solving skills.
9	(Harahap et al., 2021)	The research findings indicate the development of interactive learning media based on Android support for Problem-Based Learning (PBL) to enhance mathematical problem-solving skills.
10	(Nasrullah et al., 2025)	According to the research findings, blended learning that incorporates problem-based mathematics instruction with Edmodo and GeoGebra can be a useful alternative learning approach for enhancing students' mathematical problem-solving skills.
11	(Schmid et al., 2023)	The research findings indicate that GeoGebra serves as interactive learning media for visualizing geometric shapes in AR and VR.

No	Researcher	Research results
12	(L. Rahmawati & Nur Cahyono, 2022)	The research findings indicate that GeoGebra learning media can enhance students' problem-solving skills.
13	(Rizal et al., 2022)	The research findings indicate that the use of Math Trails media can enhance mathematical modeling skills through tourist attractions.
14	(Nurin et al., 2024)	The research findings indicate that problem-based learning using Mobile Math Trails media can enhance students' numeracy skills
15	(Jablonski et al., 2024)	The research findings indicate that teachers can use AR (Augmented Reality) and 3D printing to visualize real life.

Several studies discussing the relationship between interactive learning multimedia and mathematical problem-solving ability include: (1) examining the effect of using interactive learning multimedia on students' mathematical problem-solving ability; (2) examining the Problem-Based Learning (PBL) model assisted by interactive learning multimedia that influences mathematical problem-solving ability; (3) visualization and advanced technologies in supporting abstract mathematical thinking to figure the abstract material; (4) interactive multimedia for independent learning and student engagement as multimedia could accessible anytime and anywhere.

Effects of Interactive Learning Multimedia on Mathematical Problem-Solving Ability

The findings of this systematic literature review reveal a strong and consistent consensus regarding the effectiveness of interactive learning multimedia in enhancing students' mathematical problem-solving abilities. Across the 15 analyzed studies, interactive multimedia was found to significantly support students' capacity to understand problems, formulate solution strategies, and apply mathematical reasoning in various contexts. These findings indicate that interactive multimedia is not merely a supplementary instructional tool, but a pedagogically meaningful intervention capable of strengthening higher-order cognitive skills in mathematics.

The reviewed studies employed a wide range of interactive multimedia platforms, including Macromedia Flash, Powtoon, Canva, Articulate Storyline, Nearpod, Math Trail, GeoGebra, Camtasia Studio, and Google Sites, often integrated with instructional models such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL) (Harahap et al., 2021; Kurniawan et al., 2018). When integrated with learner-centered instructional models such as PBL and PjBL, interactive multimedia shifts the learning environment from teacher-centered instruction toward active knowledge construction. This shift supports the development of higher-order thinking skills that are essential for addressing real-world mathematical problems and aligns with current educational goals emphasizing problem-solving ability. Consequently, the findings underscore the importance of incorporating interactive learning multimedia as a strategic component of mathematics instruction to improve learning quality and better prepare students for the demands of the 21st century.

Despite differences in technological platforms and learning contexts, the outcomes consistently demonstrated improvements in students' mathematical problem-solving performance. This consistency across diverse implementations reinforces the robustness of interactive multimedia as an effective approach in mathematics education. Several studies report that students using interactive multimedia demonstrate greater persistence in solving complex problems, improved ability to evaluate solution strategies, and increased confidence in their mathematical reasoning. These outcomes suggest that interactive multimedia not only supports procedural competence but also encourages reflective thinking and strategic problem-solving. In the context of mathematics education, this is particularly important, as students are often challenged by abstract concepts that require sustained reasoning and multiple solution attempts.

Integration of Interactive Multimedia with Problem-Based and Project-Based Learning

A prominent pattern identified in the reviewed literature is the strong synergy between interactive learning multimedia and inquiry-oriented pedagogical models, particularly Problem-Based Learning (PBL). Several studies reported that multimedia designed within a PBL framework significantly enhanced students' problem-solving abilities compared to traditional or non-assisted learning approaches. For example, Sari et al. (2022) demonstrated that interactive multimedia developed using Macromedia Flash and guided by a scientific approach resulted in 78.26% of students achieving mastery in mathematical problem-solving tasks. This finding highlights the effectiveness of multimedia when aligned with structured problem-solving processes. Similarly, Sihombing and Fauzi (2024) found that Powtoon-based interactive multimedia integrated with PBL achieved high levels of validity, practicality, and effectiveness. Supporting evidence from Daryanes et al. (2023) further confirms that problem-based interactive multimedia developed using Articulate Storyline significantly improved students' problem-solving skills, as indicated by strong validation scores across material, media, and pedagogical dimensions.

The integration of interactive multimedia with PBL and PjBL also strengthens the scaffolding process in mathematics learning. Interactive multimedia can embed prompts, hints, visual cues, and feedback mechanisms that guide students through each stage of problem-solving, from problem identification to solution evaluation. This digital scaffolding supports learners with varying levels of prior knowledge and reduces dependence on direct teacher instruction. In mathematics education, such support is particularly valuable, as it allows students to progressively build problem-solving competence while maintaining autonomy and active engagement in learning tasks.

From an instructional perspective, the synergy between interactive multimedia and problem-based learning models represents a shift toward student-centered mathematics instruction. Teachers assume the role of facilitators who design learning environments that integrate technological tools with meaningful mathematical challenges. This approach aligns with contemporary educational reforms that emphasize higher-order thinking, collaboration, and problem-solving as core learning outcomes. Consequently, the integration of interactive multimedia with PBL and PjBL not only enhances students' mathematical problem-solving abilities but also contributes to the development of essential 21st-century skills, reinforcing the strategic importance of technology-enhanced problem-based learning in mathematics education. These findings also suggest that the effectiveness of interactive multimedia is amplified when it is intentionally designed to support problem-solving stages, rather than functioning as a passive content delivery medium.

Role of Visualization and Advanced Technologies in Supporting Abstract Mathematical Thinking

Another critical finding of this review concerns the role of visualization in facilitating mathematical problem-solving. Studies employing Augmented Reality (AR) and Virtual Reality (VR) technologies emphasize that transforming abstract mathematical concepts into concrete and visual representations significantly enhances students' problem comprehension and solution accuracy. Hayati et al. (2023) reported that AR-assisted project-based learning effectively improved students' problem-solving abilities by enabling learners to visualize abstract problems in more tangible forms. In line with this, GeoGebra-based learning environments integrated with AR and VR were found to be particularly effective in developing students' geometric reasoning and spatial visualization skills (Schmid et al., 2023). These findings highlight the critical pedagogical role of visualization in mathematics

education, especially in bridging the gap between abstract mathematical symbols and students' conceptual understanding.

Furthermore, the use of AR- and VR-based visualization supports conceptual transfer and long-term understanding. When students interact with visual representations that closely resemble real-world contexts, they are better able to connect abstract mathematical concepts to practical applications. This contextualization enhances students' ability to apply problem-solving strategies across different situations, an essential component of mathematical literacy. As a result, visualization technologies not only improve performance on specific tasks but also foster transferable problem-solving skills that are fundamental to mathematics learning.

Based on pedagogical standpoint, the integration of advanced visualization technologies represents a strategic innovation in mathematics instruction (Medina Herrera et al., 2024; Fokuo et al., 2023). These tools allow teachers to design learning experiences that accommodate diverse learning styles and reduce students' anxiety toward abstract mathematical content. By making invisible or abstract processes visible and interactive, AR and VR technologies help create inclusive learning environments where students can actively construct knowledge. Consequently, the findings underscore that visualization-oriented technologies are not merely technological enhancements, but powerful instructional resources that can transform the teaching and learning of mathematics, particularly in supporting students' abstract thinking and problem-solving abilities.

Interactive Multimedia for Independent Learning and Student Engagement

Beyond cognitive outcomes, several studies emphasized the contribution of interactive multimedia to independent learning and student engagement, which are essential conditions for effective problem-solving. Hafizah and Samosir (2023) demonstrated that interactive teaching materials developed using Canva enhanced students' problem-solving abilities by enabling flexible, self-paced learning through smartphone-accessible media. Similarly, Maryani et al. (2022) reported that Google Sites-based learning media integrated with PBL effectively captured students' attention and supported independent exploration of mathematical problems.

The integration of scaffolding strategies within interactive environments, such as Math Trails, further strengthens multimedia effectiveness. Math Trails media allows teachers to provide contextualized guidance tailored to students' difficulties, supporting gradual problem-solving skill development (Suryonegoro et al., 2024; Rizal et al., 2022; Fesakis et al., 2018). These findings underscore that interactivity, accessibility, and instructional support are key design principles for effective multimedia in mathematics learning.

Interactive multimedia also supports the development of self-regulated learning skills, which are closely associated with successful mathematical problem-solving. Through interactive modules, students are able to monitor their own progress, revisit learning materials, and adjust learning strategies based on feedback received. This autonomy enables learners to take greater responsibility for their learning process and fosters confidence in tackling complex mathematical problems. In mathematics education, the cultivation of self-regulation is essential, as students must often independently analyze problems, select appropriate strategies, and evaluate solution outcomes.

From an instructional and institutional perspective, the findings suggest that interactive multimedia can serve as an effective tool for promoting equitable and inclusive mathematics learning. The accessibility of multimedia platforms through widely available devices, such as smartphones, allows students from diverse backgrounds to engage in independent learning beyond the classroom. This flexibility supports differentiated instruction and helps address disparities in learning opportunities. Consequently, interactive multimedia not only

enhances student engagement and independence but also contributes to broader educational goals by supporting more inclusive and learner-centered mathematics education.

Educational Impact and Implications for Mathematics Education

The findings of this systematic literature review provide strong empirical evidence that interactive learning multimedia has a substantial impact on mathematics education, particularly in improving students' mathematical problem-solving abilities. By integrating technology with sound pedagogical frameworks such as PBL and PjBL, interactive multimedia fosters active learning, conceptual understanding, and higher-order thinking. These results align with cognitive theories, including cognitive load theory and constructivist learning theory, which emphasize the importance of visualization, interactivity, and learner engagement.

From a practical perspective, these findings have important implications for teachers, curriculum developers, and policymakers. Mathematics teachers are encouraged not only to adopt existing interactive multimedia but also to participate in the development of learning media that align with students' needs and curricular goals. For curriculum developers, the results support the systematic integration of interactive multimedia, particularly those supporting problem-based learning into mathematics curricula. At a broader level, this study highlights the potential of technology-enhanced learning to address persistent challenges in mathematics education, such as low problem-solving performance in international assessments.

Conclusion

This systematic literature review demonstrates that interactive learning multimedia has a consistently positive and significant effect on students' mathematical problem-solving abilities. Through the synthesis of empirical evidence, this study confirms that interactive multimedia, both as a standalone instructional tool and when integrated with pedagogical models such as Problem-Based Learning is effectively supports students' understanding of mathematical problems, strategy formulation, and solution implementation. These effects are primarily driven by multimedia's ability to visualize abstract concepts, promote active engagement, and facilitate independent and self-regulated learning. Consequently, interactive learning multimedia should be viewed as a pedagogically meaningful approach rather than a supplementary aid in mathematics instruction, with important implications for teachers and curriculum developers in designing student-centered learning environments. Future research is recommended to investigate the long-term and transferable effects of interactive multimedia on mathematical problem-solving, to conduct comparative studies across specific platforms and educational levels, and to examine moderating factors such as learner characteristics, instructional design quality, and learning contexts, in order to further optimize its implementation in mathematics education.

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