International Journal of Education, Management, and Technology

e-ISSN : 3026-5444
p-ISSN : 3026-4200

Index: Harvard, Boston, Sydney University, Copernicus, Lens, Scilit, Semantic, Dimensions, etc

https://doi.org/10.58578/IJEMT.v3i3.7922

Harnessing AI-Powered Learning Media in Mathematics Education: A Systematic Review on Improving Students' Problem-Solving Skills

Werdi Lestari, Gede Suweken, Sariyasa
Universitas Pendidikan Ganesha, Indonesia
werdilestari28@gmail.com

Article Info:

Submitted:	Revised:	Accepted:	Published:
Oct 3, 2025	Oct 27, 2025	Nov 8, 2025	Nov 13, 2025

Abstract

Although the integration of Artificial Intelligence (AI) in education has received growing attention, limited research has explicitly examined the development and application of AI-assisted exploratory learning media in mathematics. This study aims to analyze the characteristics, implementation, and potential effectiveness of AI-based learning tools in enhancing students' mathematical problem-solving and critical thinking skills. A Systematic Literature Review (SLR) was conducted, drawing from studies published between 2016 and 2025 in the Google Scholar and Scopus databases. Using predefined inclusion and exclusion criteria, 20 relevant articles were selected and thematically synthesized to identify prevailing trends and research gaps. The findings reveal that AI integration in mathematics education predominantly supports personalized, adaptive, and interactive learning, fostering deeper conceptual understanding and the development of higher-order thinking skills. However, few studies have focused specifically on AI-assisted mathematics learning media. Key challenges identified include insufficient teacher preparedness, ethical concerns surrounding AI deployment, and the complexity of integrating AI tools into existing curricula. The study contributes theoretically by positioning AI as a cognitive and dialogic partner in

IJEMT Journal is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License

the learning process, rather than a purely computational instrument. It also offers practical insights into the design and implementation of AI-supported learning environments. The analysis concludes that when integrated with digital tools such as EdCafe AI, GeoGebra, Scratch, and Canva, AI-assisted exploratory media can significantly enhance students' conceptual mastery and problem-solving capabilities in mathematics. The study recommends targeted teacher training, the development of ethical frameworks for AI use, and increased empirical research to support responsible, student-centered implementation of AI in mathematics education.

Keywords: Artificial Intelligence; Mathematics Learning Media; Problem-Solving; Critical Thinking; Exploratory Learning

INTRODUCTION

In recent decades, technological advancements have significantly transformed various aspects of human life, including the field of education. One of the most remarkable innovations is the integration of Artificial Intelligence (AI) into learning processes (Zafari et al., 2022). AI has been implemented in various educational domains to enhance efficiency, effectiveness, and personalization of learning for students (Sasikala & Ravichandran, 2024; Susilana et al., 2025). Furthermore, research by Holmes et al. (2021) found that AI can assist students in understanding mathematical concepts through adaptive approaches, while Weng et al. (2022) emphasized that AI-based interactions can foster students' critical thinking skills.

However, the rapid development of AI also introduces new challenges for education particularly in ensuring that technology genuinely promotes deep understanding rather than providing instant answers without thoughtful reasoning. Without appropriate strategies, AI may weaken students' critical thinking and problem-solving abilities, as they tend to depend on technology rather than engaging in meaningful analysis of the concepts being studied. Therefore, it is essential to develop innovative approaches to integrating AI as a dialogical learning partner, where AI not only serves as a tool but also as a facilitator that guides students in exploring, reasoning, and reflecting on their learning processes.

The rapid advancement of AI has also made students increasingly dependent on it for problem-solving. Many students now rely on AI to complete tasks without going through deep cognitive processes, thereby hindering the development of independent critical thinking and problem-solving skills (Badaruddin et al., 2025). This phenomenon has sparked

widespread discussion among educators and researchers regarding how AI should be utilized as a learning support tool rather than a shortcut for obtaining answers without conceptual understanding (Ulya, 2025). The challenge becomes even more complex due to the absence of clear guidelines for AI integration into curricula and the lack of teacher readiness to optimize this technology effectively in the classroom.

Research by Suharmita et al. (2024) also indicates that AI can be an effective tool for enhancing personalized learning. However, its effectiveness depends heavily on how the technology is designed and implemented in an appropriate educational context. This highlights the need for carefully planned and innovative approaches to ensure that AI functions as a medium that not only provides answers but also helps students understand concepts, develop analytical thinking, and cultivate critical and reflective questioning skills.

With the evolution of AI technology, there emerges a promising opportunity to position AI as a learning dialogue partner that guides students toward deeper conceptual understanding through prompt engineering a technique for designing structured prompts or questions that help AI produce relevant, contextual, and educational responses. The prompts generated by students can reveal how they comprehend problems and structure their reasoning processes. Based on these prompts, students' cognitive processes can be classified according to Bloom's Taxonomy (Anderson & Krathwohl, 2001), ranging from C1 (Remembering) to C6 (Creating).

AI thus serves not only as a support tool but also as a facilitator in shaping critical and systematic thinking in solving mathematical problems (Tashtoush et al., 2025). Moreover, AI-driven learning enables students to sharpen their questioning skills, building deeper conceptual understanding (Favero et al., 2024). While teachers remain central in fostering critical thinking, AI can complement their role by providing individualized, responsive, and continuous interaction something that can be challenging for teachers to manage in large classrooms.

The availability of valid, practical, and effective AI-assisted mathematics learning media designed to enhance students' problem-solving skills represents a new pedagogical innovation grounded in empirical development research. A literature search using Publish or Perish software with the keyword "Mathematics Learning Media with Artificial Intelligence" revealed 100 articles from Google Scholar and 38 from Scopus. However, only 6 Scopus articles included the term "mathematics" and 14 discussed AI; on Google Scholar, only 7

articles focused on mathematics and 85 discussed AI. These findings indicate that research on AI-assisted mathematics learning media remains limited and underexplored, warranting further investigation.

A study by Roll and Wylie (2016) also asserts that AI designed as a dialogical learning partner can help students build stronger conceptual understanding through step-by-step guidance and adaptive problem-solving. When utilized appropriately, AI can act as a catalyst for a more explorative and efficient education system, fostering meaningful learning experiences and deeper mathematical thinking (Baidoo-Anu & Owusu Ansah, 2023).

Unlike previous studies that mainly focused on literature reviews or small-scale experiments, this research introduces a new and contextual approach by developing AI-assisted learning media that are more applicable to real classroom settings. One of its core innovations is the integration of EdCafe AI into mathematics learning, designed to mitigate the potential misuse of AI as a mere answer-generating tool (Carabantes, 2020). The selection of EdCafe AI is based on its interactive and adaptive features that align with mathematics learning objectives particularly in quadratic equations and functions.

Through features such as flipcards, images, and simple animations, EdCafe AI allows teachers to visualize abstract mathematical concepts more clearly. Its AI Quiz Maker and custom AI chatbot provide personalized learning experiences and instant feedback, helping students correct misconceptions and develop independent problem-solving strategies. Teachers can also monitor students' engagement in real-time, allowing timely interventions for those who face difficulties. The integration of QR code–based access further facilitates seamless use of this technology both in-class and online.

With this combination of features, EdCafe AI serves as an innovative and effective medium for promoting active learning, increasing motivation, and fostering students' critical thinking in mathematics. AI thus evolves beyond being a mere provider of answers it becomes a stimulus for reflective and analytical thinking. This approach encourages students to analyze, evaluate, and reflect on AI-generated responses, strengthening their critical and independent problem-solving abilities (Ratnasari et al., 2024).

Mathematics is an essential subject in education, as it not only equips students with numerical competence but also cultivates analytical and logical reasoning (Wilkerson, 2020). One of the most challenging topics in mathematics is the quadratic equation, which plays a foundational role in advanced topics such as functions, algebra, and calculus, and has broad

applications in fields such as physics, economics, and engineering (Yuliana et al., 2025). However, many students struggle to grasp this concept, particularly in formulating mathematical models and solving contextual problems. AI holds great potential to address these difficulties by providing a more exploratory and adaptive learning experience.

Through Natural Language Processing (NLP), AI can engage students in educational dialogues, offer step-by-step guidance for solving quadratic equations, and present alternative problem-solving approaches suited to individual learning styles (Candiasa et al., 2025; Divayana et al., 2021). Moreover, AI can serve as a medium for developing students' questioning abilities an essential component of critical thinking. As Albert Einstein once said, "If you can formulate the question properly, you have already solved half the problem." In this context, EdCafe AI can analyze the quality of students' questions (Ardana et al., 2017), making AI not only a problem-solving tool but also an indicator of intellectual engagement (Ariawan et al., 2025; Dasari et al., 2025). This allows students to become more reflective about their understanding and improve their reasoning strategies.

Despite its great potential, the adoption of AI in education presents several challenges. One major issue lies in teachers' readiness to integrate AI effectively. Selwyn (2020) noted that many teachers still lack sufficient understanding of AI and how to incorporate it into instructional design. Thus, teacher training and professional development are essential to maximize the pedagogical use of AI in mathematics particularly in learning quadratic equations. Additionally, the implementation of AI raises ethical and pedagogical concerns (Nam & Bai, 2023), such as ensuring that AI does not replace the teacher's role as the main facilitator and addressing potential algorithmic bias that may affect learning outcomes (Alasgarova & Rzayev, 2024).

Although AI provides greater access to information and supports learning processes, concerns regarding academic integrity, including risks of dishonesty and plagiarism, remain (Mambu et al., 2023). Therefore, a balanced approach between innovation and ethics is crucial to maximize the educational benefits of AI while mitigating risks that may compromise academic credibility and quality (Ateeq et al., 2024). AI-assisted mathematics learning media must be designed with sound pedagogical principles and algorithmic transparency to ensure both ethical use and meaningful learning outcomes.

The urgency of this research lies in addressing these challenges by developing AI-assisted exploratory mathematics learning media that function as a dialogical learning partner.

This study aims to create a more engaging and exploratory learning experience that helps students better understand quadratic equations. The novelty of this research lies in the integration of EdCafe AI, Canva, Scratch, and GeoGebra into a single learning platform. This integration aims to prevent the misuse of AI as a shortcut to answers and instead encourage students to think critically, reason systematically, and reflect on their problem-solving processes.

The developed media focus on quadratic equations and functions for Grade X senior high school students, leveraging the interactive and dynamic visualization capabilities of these technologies. With the appropriate use of AI, this study is expected to make a significant contribution to improving the quality of mathematics education and preparing students to face future global challenges. To date, the development of AI-assisted exploratory learning media in mathematics particularly for quadratic equations and functions has rarely been conducted. Therefore, this research is expected to make a valuable contribution to the advancement of education by providing teachers with relevant, media-supported learning strategies aligned with current technological trends.

METHODS

Research Approach

This study employs a Systematic Literature Review (SLR) approach to provide a comprehensive and structured understanding of previous research related to the development of AI-assisted mathematics learning media. The SLR method was selected because it allows researchers to systematically identify, evaluate, and synthesize relevant studies in order to answer the formulated research questions (Ardana et al., 2023; Suardika et al., 2025). This approach aligns with Kitchenham and Charters (2007), who define *Systematic Literature Review* as a planned, transparent, and replicable process for collecting and evaluating evidence from existing studies relevant to a particular research topic.

Stages of the Systematic Literature Review

The SLR process in this study consists of three main phases: (1) Planning, (2) Conducting, and (3) Reporting. Each phase involves systematic steps, as illustrated in Figure 1.

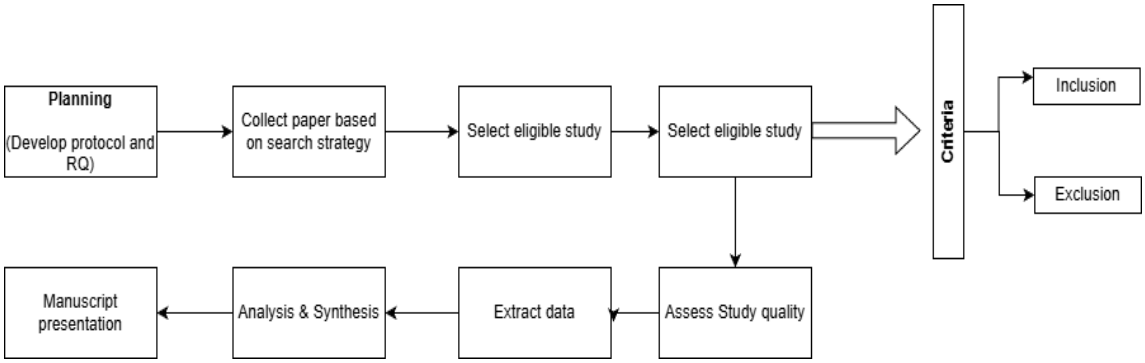

Figure 1. Stages of the Systematic Literature Review
(adapted from Kitchenham & Charters, 2007)

Figure 1 illustrates the overall workflow of the SLR process, starting from the formulation of research questions to the presentation of findings. The review process includes defining the research protocol, collecting and selecting relevant papers, evaluating study quality, extracting and synthesizing data, and reporting the results. The inclusion and exclusion criteria guide the selection of relevant and high-quality studies.

Explanation of SLR Phases

a. Planning Phase

In the planning phase, the researcher developed the review protocol and formulated the research questions (RQs) that guided the review process (Noviyanti et al., 2025). The protocol serves as a framework to ensure the review is systematic, objective, and replicable.

Key activities at this stage include:

- Defining the research objectives and scope;
- Identifying keywords such as *"Mathematics Learning Media"*, *"Artificial Intelligence in Education"*, and *"AI-based Mathematics Learning"*;
- Determining the main databases used in this review, namely Google Scholar and Scopus.

b. Conducting Phase

This phase involves implementing the SLR process, including the identification, selection, evaluation, and synthesis of relevant studies.

1. Paper Collection (Collect Paper Based on Search Strategy)

Articles were retrieved from *Google Scholar* and *Scopus* databases using the predefined keywords and Boolean search techniques.

2. Study Selection (Select Eligible Study)

The collected papers were screened using inclusion and exclusion criteria to ensure relevance and quality.

Inclusion Criteria:

- The publication is a peer-reviewed journal article;
- Published between 2017 and 2025;
- Related to mathematics learning media and the application of Artificial Intelligence (AI);
- Available in full text and written in English or Indonesian.

Exclusion Criteria:

- Non–peer-reviewed materials such as theses, proceedings, or reports;
- Studies unrelated to AI in mathematics or education;
- Articles not available in full text or inaccessible.

3. Quality Assessment (Assess Study Quality)

Each selected article was evaluated based on methodological validity, research clarity, and the consistency between research objectives, methods, and findings.

4. Data Extraction (Extract Data)

Relevant information was extracted from each selected article, including:

- Author(s) and publication year,
- Research objectives,
- Methodology,
- Main findings, and
- Relevance to AI-assisted mathematics learning media.

5. Data Analysis and Synthesis (Analysis & Synthesis)

The extracted data were analyzed to identify research patterns, themes, and trends. Narrative synthesis was then conducted to describe the current state of AI integration in mathematics learning, as well as existing challenges and research gaps.

c. Reporting Phase

The final phase involves reporting and presenting the results of the review. The synthesized findings were organized into a structured scientific report addressing the research questions, highlighting recent developments, and identifying opportunities for future research. The reporting phase also includes visual representations such as tables of article classification and thematic maps that depict emerging research trends related to AI in mathematics education.

Selection Process and Article Criteria

The literature selection process in this study was designed to ensure that only high-quality and relevant research was included in the review (Cahyaningrum et al., 2025; Ismail et al., 2025). The selection followed several stages:

1. Initial Search – A total of 138 articles were retrieved from *Google Scholar* and *Scopus* databases.

2. Title and Abstract Screening – Articles were filtered based on relevance to the topic.

3. Inclusion and Exclusion Filtering – Only studies meeting the defined criteria were retained for full-text review.

4. Content Analysis and Synthesis – Selected studies were analyzed and synthesized to extract key insights.

This process is depicted in Figure 1, which demonstrates the sequential workflow of planning, collecting, selecting, extracting, and reporting.

RESULTS

At the beginning of this study, the researcher identified and collected published research articles from reputable academic journals to serve as the foundation for the literature review. The analysis presented in this section is based on a synthesis of selected research papers obtained from the Google Scholar and Scopus databases.

Using the Publish or Perish software and the keyword *"Mathematics Learning Media with Artificial Intelligence"*, a total of 100 articles were found in Google Scholar and 38 articles in Scopus. However, within the Scopus database, only 6 research articles explicitly included the term *"mathematics"* and 14 discussed AI-related educational applications. Similarly, in Google Scholar, only 7 studies contained the keyword *"mathematics"*, while 85 papers addressed AI in general educational contexts.

These findings indicate that research specifically focused on AI-assisted mathematics learning media remains limited and relatively new. Therefore, this topic offers a promising area for further exploration and development.

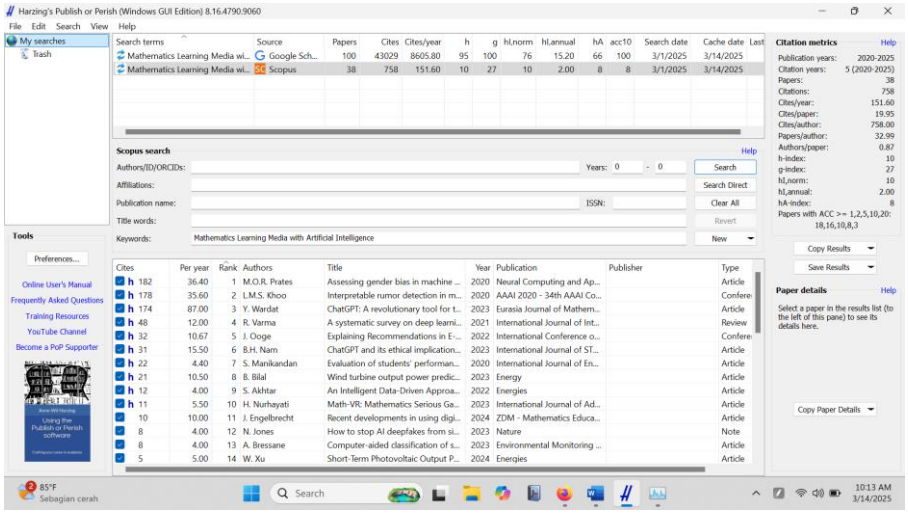

Figure 2. Publish or Perish

Based on the literature search results from Scopus and Google Scholar, the state of the art of this research can be summarized in the following table.

Table 1. Summary of Reviewed Articles on

"Mathematics Learning Media with Artificial Intelligence"

No	Author(s) / Publisher	Source	Title	Main Findings and Recommendations
1	Wardat et.al (2023) Eurasia Journal of Mathematics, Science and Technology Education	Google Scholar	ChatGPT: A Revolutionary Tool for Teaching and Learning Mathematics	ChatGPT shows great potential as a mathematical learning tool but must be used with caution and clear guidelines. It raises ethical, reliability, and critical thinking concerns that require proper pedagogical frameworks.

No	Author(s) / Publisher	Source	Title	Main Findings and Recommendations
2	Zafari et al. (2022) IEEE	Scopus	Artificial Intelligence Applications in K-12 Education: A Systematic Literature Review	Provides a comprehensive review of AI applications in K–12 education, highlighting their transformative potential, challenges, and need for policy and stakeholder involvement.
3	Carabantes (2019) AI & Society	Google Scholar	Black-box Artificial Intelligence: An Epistemological and Critical Analysis	Discusses the "black box" challenge in AI education lack of transparency and interpretability. Recommends ethical and pedagogical frameworks to ensure accountable AI integration.
4	Yu (2023) Frontiers in Psychology	Google Scholar	Reflection on whether Chat GPT should be banned by academia from the perspective of education and teaching	Examines the pros and cons of ChatGPT in education, especially risks of plagiarism and academic dishonesty; emphasizes the need for ethical regulation.
5	Baidoo-Anu & Ansah (2023) Social Science Research Network	Google Scholar	Education in the Era of Generative Artificial Intelligence (AI): Understanding the Potential Benefits of ChatGPT in Promoting Teaching and Learning	Highlights ChatGPT's potential for personalized learning and global accessibility; emphasizes balance between innovation and ethics.
6	Davies et al (2021) Nature	Google Scholar	Advancing Mathematics by Guiding Human Intuition with AI	AI assists mathematicians by discovering hidden patterns and conjectures, expanding mathematical exploration through machine learning.
7	Sinaga et al (2024) ICIESCE Conference	Google Scholar	Effectiveness of Using AI-Based Contextual Mathematics Teaching Materials on Integral Material for Improving Mathematical Problem Solving for Civil Enginering Students	AI enhances contextual learning in calculus, improving students' problem-solving skills through real-world applications.
8	Favero et al (2024) AIEER	Google Scholar	Enhancing Critical Thinking in Education by Means of a Socratic Chatbot	Introduces a Socratic AI chatbot that stimulates critical reflection through guided questioning; proven to enhance higher-order thinking.
9	Roll & Wylie (2016)	Google Scholar	Evolution and Revolution in Artificial Intelligence in Education	Identifies two main AI research trends evolutionary (classroom-based) and revolutionary (life-

No	Author(s) / Publisher	Source	Title	Main Findings and Recommendations
	International Journal of Artificial Intelligence in Education			integrated); highlights critical thinking benefits.
10	Manorat et al. (2025) Computers and Education: Artificial Intelligence	Google Scholar	Computers and Education : Artificial Intelligence Artificial intelligence in computer programming education : A systematic literature review	AI supports adaptive learning in programming, strengthening logical and mathematical reasoning skills through personalized feedback.
11	Tan et al. (2025) Computers and Education: Artificial Intelligence	Scopus	AI in Teaching and Teacher Professional Development: A Systematic Review	65% of studies focus on AI for teaching, 35% on teacher development; calls for more research on AI in teacher training, especially in mathematics.
12	Nam & Bai (2023) International Journal of STEM Education	Scopus	ChatGPT and its ethical implications for STEM research and higher education : a media discourse analysis	Highlights ChatGPT's benefits in STEM education but warns of ethical risks such as plagiarism and reduced critical originality.
13	Guan et al. (2025) Computers and Education: Artificial Intelligence	Scopus	Pre-service teachers preparedness for AI-integrated education : An investigation from perceptions , capabilities , and teachers ' identity changes ⋆	Finds positive perceptions but low readiness among pre-service teachers to integrate AI effectively in teaching mathematics.
14	Lubbe et al (2025) Education and Information Technologies	Scopus	Cultivating independent thinkers : The triad of artificial intelligence , Bloom ' s taxonomy and critical thinking in assessment pedagogy	Explores how AI and Bloom's Taxonomy enhance assessment pedagogy and foster critical, independent thinking in mathematics education.
15	Engelbrecht & Borba (2024) ZDM Mathematics Education	Scopus	Recent Developments in Using Digital Technology in Mathematics Education	Discusses AI and digital tools that improve mathematical interactivity and collaboration, emphasizing equal access and teacher readiness.
16	Yuliana et al (2025)	Scopus	Sikuadrat : Mathematics learning media with the Merdeka flow in solving	Demonstrates the effectiveness of technology-based media for quadratic equations through

No	Author(s) / Publisher	Source	Title	Main Findings and Recommendations
	Journal Salud, Ciencia y Tecnología		quadratic equations and functions	interactivity and real-time feedback.
17	Ojeda-Bazaran et al (2021) 2021 XVI Latin American Conference on Learning Technologies (LACLO)	Scopus	State of the Art of Teaching-Learning of Artificial Intelligence at Early Ages	Reviews AI education at early ages; highlights limited teacher training and curriculum support despite high potential for critical thinking.
18	Tashtoush et al. (2025), Iraqi Journal for Computer Science and Mathematics	Scopus	The Efficacy of Utilizing Artificial Intelligence Techniques in Developing Critical Thinking in Mathematics among Secondary School Students and their Attitudes Toward it	Shows that AI integration enhances students' critical thinking (deduction, inference, evaluation) and positive attitudes toward math.
19	Owan et al. (2023) Eurasia Journal of Mathematics, Science and Technology Education	Scopus	Exploring the potential of artificial intelligence tools in educational measurement and assessment Exploring the potential of artificial intelligence tools in educational measurement and assessment	Reviews AI's role in automated grading and feedback, emphasizing teacher oversight and training for ethical implementation.
20	2025 – Do Bao Chau et al., European Journal of Educational Research (EJER)	Google Scholar	Personalized Mathematics Teaching with the Support of AI Chatbots	AI chatbots enhance personalized problem-solving by adapting to students' learning styles, providing real-time guidance and feedback.

The data presented in Table 1 provides a comprehensive overview of recent research related to the integration of Artificial Intelligence in mathematics education. The reviewed studies collectively demonstrate that AI has begun to transform the landscape of mathematics learning by enhancing personalization, adaptability, and interactivity in instructional media. Most of the publications emphasize AI's potential to foster higher-order thinking skills, such as critical and reflective reasoning, as well as to improve students' problem-solving abilities through dynamic, real-time feedback mechanisms. However, despite the growing body of research on AI in education, the number of studies specifically

addressing AI-assisted mathematics learning media remains relatively small. This highlights a significant research gap and reinforces the urgency of further investigation in developing innovative, pedagogically grounded AI-based learning tools for mathematics instruction.

DISCUSSION

The findings of this study reveal that the integration of Artificial Intelligence (AI) in mathematics education has grown rapidly over the last decade, reshaping both pedagogical approaches and students' learning experiences. However, despite the increasing attention AI has received across various disciplines, research focusing specifically on AI-assisted mathematics learning media remains relatively limited. The discussion in this section highlights four major themes that emerged from the reviewed literature: (1) AI as a catalyst for personalized and adaptive learning, (2) the role of AI in enhancing critical and reflective thinking, (3) the ethical and pedagogical implications of AI in education, and (4) the research gaps that justify the development of exploratory AI-based learning media.

AI as a Catalyst for Personalized and Adaptive Learning

One of the most consistent findings across the reviewed literature is the potential of AI to create personalized and adaptive learning experiences. Studies such as those by Wardat et al. (2023), Chau et al. (2025), and Zafari et al. (2022) demonstrate that AI-based systems are capable of analyzing students' learning behaviors, adjusting instructional content, and providing real-time feedback tailored to individual needs. In mathematics education, this level of personalization represents a significant shift from the traditional "one-size-fits-all" approach to a more learner-centered paradigm. AI technologies such as chatbots, intelligent tutoring systems, and machine learning algorithms enable teachers to deliver content that aligns with each student's cognitive ability, pacing, and preferred learning style. For example, Chau et al. (2025) utilized AI chatbots to personalize mathematics problem-solving tasks for Vietnamese high school students, leading to measurable improvements in problem-solving accuracy and motivation. Similarly, Sinaga et al. (2025) found that AI-driven contextual mathematics materials helped civil engineering students better connect theoretical concepts with real-world applications. These findings affirm that the adaptive nature of AI contributes not only to efficiency in learning but also to equity, ensuring that each learner receives the necessary support to achieve optimal understanding.

AI and the Development of Critical and Reflective Thinking

Another dominant theme emerging from this review is AI's potential to foster higher-order thinking skills, particularly critical and reflective thinking. Several studies (Favero et al., 2024; Tashtoush & Qasimi, 2025; Lubbe et al., 2025) highlight how AI, when designed as an interactive dialogue partner rather than a simple answer generator, can guide students to question, analyze, and evaluate mathematical concepts more deeply. Favero et al. (2024) introduced a Socratic Chatbot capable of stimulating critical reflection through structured prompts and guided questioning. Rather than providing direct answers, the system engages students in metacognitive dialogue helping them explore multiple perspectives and justify their reasoning. Similarly, Tashtoush and Qasimi (2025) demonstrated that AI integration in mathematics significantly improved students' deductive, inferential, and evaluative skills, leading to more meaningful learning outcomes. These studies align with the principles of Bloom's Revised Taxonomy (Anderson & Krathwohl, 2001), suggesting that AI can effectively support learning at higher cognitive levels (C4–C6: analyzing, evaluating, and creating). In this sense, AI acts as a thinking facilitator, encouraging learners to move beyond procedural understanding toward conceptual mastery. For mathematics education, which often emphasizes procedural fluency, this shift is transformative it redefines AI as a co-thinker that supports inquiry, reasoning, and self-regulated learning.

Ethical and Pedagogical Considerations

Despite its potential, the reviewed studies also emphasize a number of ethical and pedagogical challenges in AI adoption (Carabantes, 2020; Nam & Bai, 2023; Kau et al., 2023). These challenges include data privacy concerns, algorithmic bias, dependency on automation, and the risk of academic dishonesty. As pointed out by Kau et al. (2023), the emergence of tools like ChatGPT has prompted debates within the academic community regarding their proper use. While these tools can enhance accessibility and efficiency, they also raise questions about originality and intellectual integrity. Similarly, Carabantes (2020) critiques the "black-box" nature of AI where decision-making processes are opaque posing challenges for accountability and transparency in educational settings. Furthermore, Nam and Bai (2023) highlight that teachers often lack adequate training to integrate AI effectively into classroom practice. This aligns with Guan et al. (2025), who found that pre-service teachers generally possess positive perceptions of AI but insufficient readiness to apply it pedagogically. These

findings underline the importance of teacher professional development and AI literacy in ensuring that technology enhances rather than replaces the pedagogical role of educators. Thus, ethical implementation requires balancing innovation with responsibility ensuring that AI systems in education remain transparent, fair, and human-centered.

The Need for Exploratory AI-Based Learning Media

The synthesis of literature further reveals a research gap in the development of exploratory learning media that actively engage students in reasoning and problem-solving processes. While numerous studies examine AI in general learning contexts, only a few have focused on AI-assisted mathematics learning tools designed to stimulate exploration and inquiry. The limited number of studies found in both Scopus and Google Scholar databases only 6 explicitly combining "mathematics" and "artificial intelligence" indicates that this research field remains underdeveloped. Moreover, most existing studies are conceptual or review-based, with only a small proportion employing empirical or experimental designs to test the effectiveness of AI in mathematics learning. In this regard, the current research contributes to the field by proposing the development of AI-assisted exploratory mathematics learning media that integrates tools such as EdCafe AI, GeoGebra, Scratch, and Canva. This combination aims to facilitate visual, interactive, and reflective learning experiences while preventing students from relying solely on AI for instant answers. Instead, AI will serve as a dialogic learning partner, guiding students through structured prompts that require analysis, evaluation, and creative thinking. By positioning AI as a cognitive scaffold rather than a shortcut, this research supports a paradigm shift toward meaningful, inquiry-driven learning in mathematics.

Implications for Educational Practice

The integration of AI in mathematics education has several implications for teachers, students, and educational institutions.

1. For teachers, AI can serve as a diagnostic and formative assessment tool that helps identify students' learning difficulties and provide immediate feedback. However, teachers must be equipped with digital and AI pedagogical competencies to effectively manage AI-mediated learning environments.

2. For students, AI provides opportunities for deeper engagement and autonomy in learning, enabling them to take ownership of their progress through interactive and personalized experiences.

3. For educational institutions, the findings suggest the need to establish clear policies, ethical guidelines, and support systems for implementing AI-based learning technologies responsibly.

Furthermore, the integration of AI should not aim to replace teachers but to augment human intelligence creating a collaborative ecosystem where human and artificial intelligence work in synergy to enhance the quality of learning.

CONCLUSION

This study conducted a Systematic Literature Review (SLR) to explore the development and application of Artificial Intelligence (AI)-assisted mathematics learning media. The review synthesized twenty relevant studies published between 2016 and 2025 from Scopus and Google Scholar databases. The findings reveal that AI has begun to transform mathematics education by enabling personalized, adaptive, and interactive learning experiences that foster deeper conceptual understanding and critical thinking. Through adaptive feedback, dialogic AI models, and contextualized learning materials, AI has demonstrated its potential to shift mathematics education from procedural learning toward reflective and inquiry-based learning. However, the analysis also shows that the number of empirical studies focusing specifically on AI-assisted mathematics learning media remains limited, and challenges related to ethical use, teacher readiness, and curriculum integration persist.

The scientific contribution of this study is threefold. Theoretically, it strengthens the understanding that AI can function not merely as a computational aid but as a *cognitive and dialogic partner* in learning, aligning with constructivist and metacognitive learning theories. Methodologically, this research offers a systematic synthesis of the current state of the art, identifying dominant themes, effective practices, and gaps in existing literature that provide a foundation for subsequent empirical inquiry. Practically, the study highlights the pedagogical potential of integrating platforms such as EdCafe AI, GeoGebra, Scratch, and Canva into mathematics instruction to create exploratory, student-centered, and ethically guided learning environments that enhance problem-solving and analytical reasoning skills.

Based on the identified gaps, several recommendations are proposed for future research. First, there is a need for empirical and experimental studies that evaluate the effectiveness of AI-assisted learning media in improving specific mathematical competencies, such as problem-solving and critical reasoning. Second, teacher professional development should be prioritized to build AI literacy and pedagogical readiness for technology-integrated instruction. Third, future studies should focus on ethical frameworks and policy development to guide the responsible use of AI in education, ensuring transparency, fairness, and academic integrity. Finally, cross-disciplinary and localized studies particularly within the Indonesian educational context are encouraged to design culturally relevant AI-based learning models.

Overall, this study contributes to bridging the gap between technological advancement and pedagogical innovation, positioning AI as a transformative force in mathematics education that supports not only knowledge acquisition but also the cultivation of independent, critical, and reflective learners.

REFERENCES

Ardana, I. M., Ariawan, I. P. W., & Divayana, D. G. H. (2017). Measuring the Effectiveness of BLCS Model (Bruner , Local Culture , Scaffolding) in Mathematics Teaching by using Expert System-Based. *International Journal Education and Management Engineering*, *4*(July), 1–12. https://doi.org/10.5815/ijeme.2017.04.01

Ardana, I. M., Ariawan, I. P. W., & Sugandini, W. (2023). Character Development Through Collaboration Between Teachers , Parents , and Students in Online Learning. *Jurnal Edutech Undiksha*, *11*(1), 11–19. https://doi.org/10.23887/jeu.v11i1.62680

Ariawan, I. P. W., Suyasa, P. W. A., Adiarta, A., Sukawijana, I. K. G., Santiyadnya, N., & Divayana, D. G. H. (2025). User Interface Design of Digital Test Based on Backward Chaining as a Measuring Tool for Students ' Critical Thinking. *International Journal of Advanced Computer Science and Applications*, *16*(1), 584–590. https://doi.org/10.14569/IJACSA.2025.0160156

Badaruddin, B., Parhanuddin, L., Tohri, A., & Suhardi, M. (2025). The Effect of AI (Artificial Intelligence) in Education on Student Motivation : A Systematic Literature Review. *Journal for Lesson and Learning Studies*, *8*(1), 1–10. https://doi.org/10.23887/jlls.v8i1.91141

Baidoo-anu, D., & Ansah, L. O. (2023). Education in the Era of Generative Artificial Intelligence (AI): Understanding the Potential Benefits of ChatGPT in Promoting Teaching and Learning. *Journal of AI*, *7*(1), 52–62. https://doi.org/10.3845963/joai.10vi19.395

Cahyaningrum, K. A. K., Ardana, I. M., & Suweken, G. (2025). Development of a Problem-Based Interactive E-Module with Social Emotional Learning in Tri Hita Karana to

Enhance Mathematical Problem-Solving and Noble Character. *International Journal of Education, Management, and Technology*, *3*(1), 360–374. https://doi.org/10.58578/ijemt.v3i1.5169

Candiasa, I. M., Mertasari, N. M. S., Sastri, N. L. P. P., & Oya, A. (2025). Variation of problem-posing approaches to improve learning outcomes and problem-posing abilities of prospective mathematics teachers. *Journal of Education and E-Learning Research*, *12*(3), 374–381. https://doi.org/10.20448/jeelr.v12i3.6911

Carabantes, M. (2019). Black-box artificial intelligence : an epistemological and critical analysis. *AI & SOCIETY*, *14*(10), 1–19. https://doi.org/10.1007/s00146-019-00888-w

Dasari, D., Hendriyanto, A., Ariawan, I. P. W., Muhaimin, L. H., & Pahmi, S. (2025). Crafting epistemic knowledge in statistics education via didactical engineering integrating the theory of didactical situations and the SECI model. *Discover Sustainability*, *6*(928), 1–32. https://doi.org/10.1007/s43621-025-01838-x

Davies, A., Veličković, P., Buesing, L., Blackwell, S., Zheng, D., Tomašev, N., Tanburn, R., Battaglia, P., Blundell, C., Juhász, A., Lackenby, M., Williamson, G., Hassabis, D., & Kohli, P. (2021). Advancing mathematics by guiding human intuition with AI. *Nature*, *600*(December), 70–79. https://doi.org/10.1038/s41586-021-04086-x

Divayana, D. G. H., Suyasa, P. W. A., & Widiartini, N. K. (2021). An innovative model as evaluation model for information technology-based learning at ICT vocational schools. *Heliyon*, *7*(2), 1–15. https://doi.org/10.1016/j.heliyon.2021.e06347

Engelbrecht, J., & Borba, M. C. (2024). Recent developments in using digital technology in mathematics education. *ZDM – Mathematics Education*, *56*(2), 281–292. https://doi.org/10.1007/s11858-023-01530-2

Favero, L., Pérez-ortiz, J. A., Käser, T., & Oliver, N. (2024). Enhancing Critical Thinking in Education by means of a Socratic Chatbot. *AIEER*, *12*(1), 1–11. https://doi.org/10.2409/aieer.05511v1

Guan, L., Zhang, Y., & Gu, M. M. (2025). Pre-service teachers preparedness for AI-integrated education : An investigation from perceptions , capabilities , and teachers ' identity changes ⋆. *Computers and Education: Artificial Intelligence*, *8*(December 2024), 100341. https://doi.org/10.1016/j.caeai.2024.100341

Ismail, N. S., Mertasari, N. M. S., & Widiartini, N. K. (2025). The Impact of Problem-Based Learning and HOTS Based Formative Tests on Critical Thinking. *International Journal of Humanities, Education, and Social Sciences*, *3*(1), 26–46. https://doi.org/10.58578/IJHESS.v3i1.4296

Lubbe, A., Marais, E., & Kruger, D. (2025). Cultivating independent thinkers : The triad of artificial intelligence , Bloom ' s taxonomy and critical thinking in assessment pedagogy. In *Education and Information Technologies* (Vol. 30, Issue 12). Springer US. https://doi.org/10.1007/s10639-025-13476-x

Manorat, P., Tuarob, S., & Pongpaichet, S. (2025). Computers and Education : Artificial Intelligence Artificial intelligence in computer programming education : A systematic literature review. *Computers and Education: Artificial Intelligence*, *8*(April), 100403. https://doi.org/10.1016/j.caeai.2025.100403

Nam, B. H., & Bai, Q. (2023). ChatGPT and its ethical implications for STEM research and higher education : a media discourse analysis. *International Journal of STEM Education*, *10*(66), 1–24. https://doi.org/10.1186/s40594-023-00452-5

Noviyanti, P. L., Ardana, I. M., & Supartha, I. N. (2025). Analysis of Students ' Academic Self-Concept and Metacognitive Skills in Problem-Based Learning in Senior High School. *International Conference Proceedings Universitas Islam Balitar Blitar*, *1*(1), 436–446.

Ojeda-Bazaran, M.-Jo., Chamba-Eras, L., Labanda-Jaramillo, M., Fierro-Saltos, W., Conde-Zhingre, L., Orellana-Malla, A., Romero-Flores, M., Cueva-Alvarado, G., Irene-Robalino, D., Chamba-Eras, I., & Erreyes-Pinzon, D. (2021). State of the Art of Teaching-Learning of Artificial Intelligence at Early Ages. *2021 XVI Latin American Conference on Learning Technologies (LACLO)*, *1*(October), 1–9. https://doi.org/10.1109/LACLO54177.2021.00024

Owan, V. J., Abang, K. B., & Idika, D. O. (2023). *Exploring the potential of artificial intelligence tools in educational measurement and assessment Exploring the potential of artificial intelligence tools in educational measurement and assessment*. *June*. https://doi.org/10.29333/ejmste/13428

Roll, I., & Wylie, R. (2016). Evolution and Revolution in Artificial Intelligence in Education. *International Journal of Artificial Intelligence in Education*, *26*(1), 582–599. https://doi.org/10.1007/s40593-016-0110-3

Sasikala, P., & Ravichandran, R. (2024). Study on the Impact of Artificial Intelligence on Student Learning Outcomes. *Journal of Digital Learning and Education*, *04*(2), 145–155. https://doi.org/10.52562/jdle.v4i2.1234

Sinaga, E. K., Panjaitan, N. H., & Suhairiani, S. (2024). Effectiveness of Using AI-Based Contextual Mathematics Teaching Materials on Integral Material for Improving Mathematical Problem Solving for Civil Enginering Students. *Proceedings of the 6th International Conference on Innovation in Education, Science, and Culture, ICIESC 2024*, *6*(1), 1–7. https://doi.org/10.4108/eai.17-9-2024.2353023

Suardika, I. M. D., Pujawan, I. G. N., & Divayana, D. H. (2025). Effect of Problem-Based Learning with Interactive Animation Videos on Math Problem-Solving and Critical Thinking Skillstype. *International Journal of Education, Management, and Technology*, *3*(1), 13–29. https://doi.org/10.58578/IJEMT.v3i1.4320

Suharmita, S., Mulyono, M., Fauzi, K. A., & Suharyanisa, S. (2024). Development of E-Modul Based on a Problem Based Learning Model to Improve Problem Solving Ability and Appreciation of Mathematics at SMP Dharma Pancasila Medan. *Prima: Jurnal Pendidikan Matematika*, *8*(2), 416. https://doi.org/10.31000/prima.v8i2.11227

Susilana, R., Setiawan, B., & Rahayu, S. (2025). Soft Skills in Jeopardy : The Impact of AI on Future Generations of Students. *Indonesian Journal of Educational Research and Review*, *8*(1), 133–145. https://doi.org/10.23887/ijerr.v8i1.82875

Tan, X., Cheng, G., & Ling, M. H. (2025). Computers and Education : Artificial Intelligence Artificial intelligence in teaching and teacher professional development : A systematic review. *Computers and Education: Artificial Intelligence*, *8*(October 2024), 100355. https://doi.org/10.1016/j.caeai.2024.100355

Tashtoush, M. A., Qasimi, A. B., & Hussein, L. A. (2025). The Efficacy of Utilizing Artificial Intelligence Techniques in Developing Critical Thinking in Mathematics among

Secondary School Students and their Attitudes Toward it. *Iraqi Journal for Computes Sciences and Mathematics*, *6*(1), 37–50.

Ulya, V. H. (2025). Development of AI-Based Learning E-Module with Discovery Learning Approach to Improve Students' Mathematical Problem-Solving Ability. *Jurnal Univ Pendidikan Ganesha*, *4*(1), 341–354.

Wardat, Y., Tashtoush, M. A., AlAli, R., & Jarrah, A. M. (2023). ChatGPT : A revolutionary tool for teaching and learning mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(7), 1–18. https://doi.org/10.29333/ejmste/13272

Yu, H. (2023). Reflection on whether Chat GPT should be banned by academia from the perspective of education and teaching. *Frontiers in Psychology*, *14*(1181712), 1–12. https://doi.org/10.3389/fpsyg.2023.1181712

Yuliana, Y., Tukiyo, T., Tasari, T., & Kurdhi, N. A. (2025). Sikuadrat : Mathematics learning media with the Merdeka flow in solving quadratic equations and functions. *Salud, Ciencie y Technologia*, *5*(1031), 1–15. https://doi.org/10.56294/saludcyt20251031

Zafari, M., Bazargani, J. S., Sadeghi-niaraki, A., & Choi, S. (2022). Artificial Intelligence Applications in K-12 Education : A Systematic Literature Review. *IEEE Access*, *10*(June), 61905–61921. https://doi.org/10.1109/ACCESS.2022.3179356