ENHANCING DEEP LEARNING IMPLEMENTATION THROUGH INNOVATIVE INTEGRATION OF MATHEMATICS LEARNING TECHNOLOGY

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ABSTRACT
This study aims to elaborate on the role of digital technology in strengthening deep learning in mathematics learning. The method used is a literature review of national and international indexed articles (2020–2025) relevant to the topics of concept visualization through Desmos, GeoGebra, and AR, the use of artificial intelligence and learning analytics, the technology-based Realistic Mathematics Education (RME) approach, and the use of online collaborative platforms. The results of the study indicate that interactive visualization facilitates the understanding of abstract concepts, AI is able to provide adaptive feedback and personalized learning, technology-based RME links concepts to more meaningful real-world contexts, and collaborative platforms encourage communication skills and mathematical reflection. However, the success of integration is greatly influenced by teacher readiness, digital literacy, and adaptive curriculum and institutional support. Thus, technology is not just a tool, but becomes a pedagogical partner to deepen students' mathematical understanding.

Keywords: Mathematics Learning, Digital Technology, Deep Learning

BACKGROUND

The development of digital technology over the past decade has brought significant changes to education, particularly in mathematics learning. Technology integration serves not only as a visual aid but also fosters deep learning, emphasizing meaningful understanding, critical thinking, and advanced problem-solving skills (Fatmawaty, 2024; Fitriani & Santiani, 2025)In this context, mathematics learning is no longer sufficient to simply emphasize formula memorization, but rather needs to be directed towards learning experiences that allow students to explore concepts more deeply through the integration of innovative technology.

Numerous studies have shown that the application of deep learning in mathematics education can improve student motivation, self-confidence, and even academic achievement. For example, the technology-based Realistic Mathematics Education (RME) approach has been shown to be effective in connecting abstract concepts with real-life situations, thereby strengthening the meaning of learning (Rahayu et al., 2025; Tañola & Lomibao, 2024). Similarly, the use of interactive media based on deep learning encourages elementary school students to develop curiosity, critical thinking skills, and mathematical problem-solving abilities (Mailani et al., 2025; Ratnasari et al., 2025).

The integration of cutting-edge technologies, such as Artificial Intelligence (AI), Learning Analytics, Augmented Reality (AR), and Virtual Reality (VR), is increasingly expanding the opportunities for applying deep learning to education. AI and machine learning, for example, are not only useful in the healthcare sector through disease prediction (Abdillah et al., 2024), but also opens new avenues in personalizing mathematics learning according to students' learning styles (Awang et al., 2025; Maulida et al., 2024). In addition, the use of AR and VR in education has been proven to increase student engagement through immersive learning experiences that stimulate creative and collaborative thinking skills (Arsyad et al., 2025; Efendi & Asrizal, 2025)However, implementing deep learning through the integration of mathematics technology is not without challenges. The main obstacles schools face are limited ICT infrastructure, teachers' digital literacy, and ethical concerns regarding data privacy in the use of learning analytics (Hanifah et al., 2025; Zou et al., 2025). In addition, the curriculum, which still tends to focus on basic cognitive achievement, often does not fully support meaningful technology-based learning (Muvid, 2024; Wijaya, 2025).

However, the opportunities are far greater. Integrating mathematics technology with a deep learning approach has the potential to produce a generation of 21st-century learners who possess critical, creative, collaborative, and communicative thinking skills (the 4Cs). With the support of appropriate pedagogical strategies, teachers can leverage innovative technology to strengthen the connection between theory and practice, build students' intrinsic motivation, and create adaptive and personalized learning experiences (Hamzah et al., 2024; A. Hidayat & Firmanti, 2024).

Based on this description, it is clear that enhancing the implementation of deep learning through the integration of mathematics learning technology is a strategic step in addressing the challenges of modern education. Further research and development are needed to find the most effective, inclusive, and sustainable integration model, so that technology truly becomes a catalyst for achieving better quality education.

RESEARCH METHOD

This study uses a literature study method that aims to examine the integration of technology in mathematics learning to strengthen the application of deep learning. The literature sources used come from reputable international and national journal articles, conference proceedings, and research reports indexed in databases such as Scopus, Web of Science, ERIC, Google Scholar, and Garuda/Sinta for national literature. The search strategy was carried out by utilizing a combination of keywords, both in English and Indonesian, such as "deep learning in mathematics education", "technology integration in mathematics learning", "AI and learning analytics in education", "augmented reality/virtual reality mathematics", and "technology integration in mathematics learning". Boolean operators (AND, OR) are used to expand or narrow the search results, for example "deep learning" AND "mathematics education" or "GeoGebra OR Desmos" AND "conceptual understanding".

The inclusion criteria used in the literature selection include: (1) articles published between 2020–2025 to ensure relevance to the latest developments, (2) studies focused on the integration of technology in mathematics learning such as AR, VR, AI, learning analytics, and interactive digital applications, (3) discussing the relationship between technology and the implementation of deep learning in terms of conceptual understanding, problem solving, critical thinking, and 21st-century skills, (4) available in accessible full-text, and (5) written in English or Indonesian. Meanwhile, exclusion criteria were set to exclude irrelevant articles, such as publications that only touch on deep learning in a non-educational context (e.g., computer science or health without relevance to mathematics learning), non-peer-reviewed articles such as editorials or popular opinions, duplicate articles that appear in more than one database, and publications that do not present adequate empirical data or conceptual analysis.

The research was conducted systematically through six steps. First, the identification stage, which included formulating research questions and determining search keywords. Second, the initial selection stage, which assessed the relevance of articles based on their titles and abstracts. Third, the screening stage, which used inclusion-exclusion criteria, ensured that only articles that matched the research focus were selected. Fourth, data extraction from selected articles, by recording important information such as author names, year of publication, research context, type of technology used, key findings related to deep learning implementation, and identified challenges and opportunities, was carried out. Fifth, data analysis and synthesis, in which the literature was grouped into broad themes, such as visualization of mathematical concepts, AI & learning analytics, technology-based RME, virtual classrooms and digital collaboration, teacher training, and AR/VR/IoT-based curricula. Sixth, the reporting stage, in which findings were presented in a structured narrative format, supplemented with tables and thematic maps to demonstrate patterns and relationships between studies.

RESEARCH FINDINGS

Based on the literature selection process using inclusion and exclusion criteria, 28 relevant articles were obtained published between 2020–2025 from various reputable international journals and national journals indexed by Sinta/DOAJ. These articles discuss the integration of technology in mathematics learning to strengthen the implementation of deep learning, with a range of themes such as: (1) visualization of mathematical concepts through digital applications (Desmos, GeoGebra, AR/VR), (2) utilization of artificial intelligence (AI) and learning analytics, (3) implementation of technology-based Realistic Mathematics Education, (4) utilization of virtual classrooms and digital collaboration, and (5) curriculum strategies and teacher training to support digital literacy in mathematics learning.

Table 1. Summary of Literature Study Results

No	Author & Year	Number of Articles	Technology/Strategy Focus	Key Findings
1	(Dhani et al., 2022; Fathurrahman & Fitrah, 2023; Mediana Jr & Dio, 2025; Rafi & Sabrina, 2019)	3	Concept visualization with Desmos, GeoGebra, AR	Enhancing students' conceptual understanding and motivation through interactive simulations
2	(Abdillah et al., 2024; Awang et al., 2025; Joseph & Uzondu, 2024; Maulida et al., 2024; Zou et al., 2025)	5	AI & Learning Analytics	Personalization of learning, diagnosis of learning difficulties, while raising data privacy issues
3	(Rahayu et al., 2025; Tañola & Lomibao, 2024)	2	Technology-based Realistic Mathematics Education	Connecting mathematics to real-life contexts, increasing learning motivation
4	(Awang et al., 2025; Engelbrecht & Borba, 2024; Hamzah et al., 2024)	3	Virtual classroom & digital collaboration	Facilitating learning across space/time, challenging to maintain student engagement
5	(Muvid, 2024; Sugandi et al., 2025)	2	Teacher training for digital media	Improving teachers' digital literacy and pedagogy, but facing resistance due to workload
6	(Arsyad et al., 2025; Fatmawaty, 2024; Maharani et al., 2025)	3	AR/VR/IoT based curriculum	Providing immersive learning experiences, shaping 21st century skills
7	(Hayati, 2025; AG Hidayat & Haryati, 2025; Mailani et al., 2025; Novita Barokah & Umi Mahmudah, 2025; Ratnasari et al., 2025)	5	Deep learning in elementary and middle school	Improve critical thinking skills, problem solving, and self-confidence
8	(Mulyanto et al., 2025; Sugandi et al., 2025; Yanuar et al., 2025)	3	Deep learning for high school/vocational school teachers	Helping teachers prepare meaningful learning, but requires curriculum support

The study results show that technology integration in deep learning-based mathematics instruction has significant potential to improve the quality of learning. For example, the use of Desmos and GeoGebra (Mediana Jr & Dio, 2025) has proven effective in facilitating the visual exploration of abstract mathematical concepts. Meanwhile, the application of AI and learning analytics enables personalized learning, although it raises concerns about data privacy (Awang et al., 2025; Zou et al., 2025). In addition, the technology-based RME approach encourages the connection of mathematics learning with real-life contexts (Rahayu et al., 2025), while the use of virtual classrooms and collaborative tools opens up opportunities for cross-regional learning(Engelbrecht & Borba, 2024)However, teacher resistance and limited digital infrastructure remain major obstacles (Muvid, 2024; Sugandi et al., 2025) in general, this study confirms that the success of technology integration in deep mathematics learning is greatly influenced by teacher readiness, curriculum support, infrastructure availability, and appropriate pedagogical understanding

DISCUSSION

The integration of technology into mathematics learning has become a crucial strategy for strengthening the implementation of deep learning. The reviewed articles demonstrate that technology serves not only as a tool but also as a pedagogical medium capable of fostering conceptual understanding, collaboration, personalized learning, and 21st-century skills. The following discussion is structured around five main themes.

1. Visualization of Mathematical Concepts through Digital Applications (Desmos, GeoGebra, AR/VR)

Visualizing mathematical concepts through digital applications such as Desmos, GeoGebra, and augmented reality (AR) has become an important strategy in supporting deep learning because it can transform abstract concepts into more concrete and interactive learning experiences (Dhani et al., 2022; Nasution et al., 2022). With its dynamic graphing feature, Desmos, for example, allows students to directly manipulate parameters, allowing them to understand relationships between variables not only procedurally but also conceptually. Similarly, GeoGebra integrates algebra, geometry, and calculus through interconnected visual representations, allowing students to explore mathematical properties through multiple representations.

Furthermore, AR technology provides added value by providing an immersive experience in learning three-dimensional shapes, vectors, and geometric transformations. This experience stimulates spatial reasoning and expands students' imaginations, a challenge difficult to achieve with conventional media. This is in line with the findings Hanifah et al. (2025); Mediana Jr & Dio (2025), this digital media integration has been proven to enrich the critical and reflective thinking process because students not only receive information, but also have the opportunity to test hypotheses, analyze patterns, and find meaning from the exploration process they undertake.

Besides that Efendi & Asrizal (2025) emphasizes that interactive simulations through digital media can bridge mathematical concepts with real-world applications, for example in the context of modeling physical, economic, or social phenomena. This connection is at the heart of deep learning, as students not only master calculation algorithms but also understand the relevance of mathematics in everyday life and other disciplines.

Application Examples

a. **GeoGebra for quadratic functions**. The teacher asks students to shift the coefficients, and on the quadratic function. With the graph visualization changing in real-time, students can connect algebraic concepts with the geometric representation of a parabola.$abcy = ax^2 + bx + c$

b. **Desmos for trigonometry**Students explore graphs of sine and cosine functions by varying amplitude, frequency, and phase. This activity reinforces the understanding that each parameter has a direct influence on the waveform.

c. **AR for 3D geometry**. Through the AR app, students can "place" geometric shapes (e.g., pyramids or prisms) on their desks, rotate them, measure edge lengths, and observe intersections. These activities help students develop a better understanding of spatial geometry.

2. Utilization of Artificial Intelligence (AI) and Learning Analytics

Artificial Intelligence (AI) and learning analytics open up significant opportunities for personalized mathematics learning, a practice that has been difficult to achieve with conventional approaches. AI-based systems can analyze student learning patterns in real time and provide adaptive feedback tailored to each individual's ability level, pace, and learning style (Joseph & Uzondu, 2024). Thus, learning is no longer uniform, but more responsive to students' unique needs. This supports deep learning because students are guided to deepen concepts they haven't yet mastered while simultaneously receiving challenges appropriate to their development.

According to Abdullah et al. (2024); Zou et al. (2025) this technology is capable of quickly identifying specific student difficulties, such as misconceptions in algebra or errors in understanding graphical representations. Based on these findings, the AI system can provide more targeted learning activity recommendations, including additional practice questions, alternative visualizations, and explanations tailored to the student's cognitive style. This process not only addresses weaknesses but also stimulates self-regulated learning, a crucial pillar of deep learning.

However, there are challenges that need to be addressed. First, data privacy and security are key concerns, as AI and learning analytics rely on the collection and analysis of student data on a large scale. Second, many teachers are still not optimally utilizing data analytics to inform pedagogical decisions (Efendi & Asrizal, 2025)**.** Improving teachers' digital literacy is absolutely necessary so that this technology truly becomes a supporter of deeper learning strategies, not just a tool for automating problem solving.

With this perspective, AI should not be positioned merely as a “quick-correction machine,” but as a pedagogical partner that helps teachers understand students’ learning patterns, design more contextual interventions, and create more personalized, reflective, and meaningful learning experiences.

Application Examples

a. **AI-based chatbot**. Used to answer students' questions outside of class hours with adaptive explanations according to their level of understanding.

b. **Learning analytics dashboard**. Teachers can visually see individual and class progress (for example, students who repeatedly fail to understand the concept of limits), and then redesign learning strategies.

c. **Adaptive assessment.** A test system that adjusts the difficulty level of questions based on student responses, so that assessment results more accurately reflect actual competency.

3. Implementation of Technology-Based Realistic Mathematics Education (RME)

Technology-based Realistic Mathematics Education (RME) presents a learning approach that emphasizes the connection between mathematical concepts and students' real experiences through the use of digital media (Putri et al., 2024)The core principle of RME, "mathematics as a human activity," can be further strengthened with the support of digital technologies that provide rich, interactive, and accessible contexts. In this way, mathematics is no longer viewed as a collection of abstract symbols, but rather as a means of understanding, analyzing, and solving problems in everyday life.

According to Rahayu et al. (2025) digital technology expands the range of realistic contexts teachers can use in learning. For example, through economic simulations, students can learn the concepts of percentages and exponential growth; using a GPS can clarify the concepts of distance and coordinates; while simple big data analysis of social phenomena can support understanding of statistics and probability. These rich contexts motivate students to learn more deeply because they see the direct relevance of mathematics in their lives.

Besides that, Tañola & Lomibao (2024) emphasizes the importance of adapting to local contexts through digital media. For example, teachers can use local rainfall data to teach the concept of averages, or use interactive simulations of local transportation to explain route optimization. This approach makes it easier for students to construct meaning from abstract concepts because they can connect everyday experiences with mathematical representations.

Thus, technology-based RME is not just context enrichment but also a foundation for supporting deep learning. Students learn to discover connections between personal experiences, social phenomena, and mathematical symbols, while simultaneously practicing critical thinking and problem-solving skills in real-life situations.

Application Examples

a. **Digital Financial Simulation**. Using a spreadsheet application to calculate interest on savings or loans, so that students understand the concepts of percentages, compound interest, and exponentials.

b. **GeoGebra and Real Data.** Students analyze their city's daily temperature data, model it as a function, and then predict weather trends.

c. **GPS Application.** Using a digital map application, students calculate distance, travel time, and optimal routes; this activity connects geometry and trigonometry concepts to everyday mobility.

4. Utilization of Virtual Classrooms and Digital Collaboration

Virtual classroom platform and digital collaboration tools such as Google Classroom, Microsoft Teams, and Padlet have changed the paradigm of mathematics learning to be more flexible, not limited by space and time (Zhilmagambetova, 2023). Through this digital ecosystem, teachers can distribute materials, assign assignments, and monitor student progress in a more structured manner. More importantly, this platform enables both asynchronous and synchronous interactions, allowing students to learn at their own pace while remaining connected within the learning community. According to Engelbrecht & Borba (2024) the success of online mathematics learning depends not only on technology but also on interactive design that fosters active student participation. Rich interactions encourage students to ask questions, discuss strategies, and construct shared understanding. Without this active engagement, technology serves merely as a repository of material, not a facilitator of deep learning.

Meanwhile, Hamzah et al. (2024) demonstrated that the use of digital collaborative tools strengthened students' mathematical communication skills. Through online group discussions, students not only presented answers but also argued for solutions, listened to their peers' alternative thinking, and reflected on their strategies. This process fostered mathematical discourse, a crucial skill for deep conceptual understanding. Furthermore, Awang et al. (2025) highlights the potential for cross-regional collaboration facilitated by digital platforms. Students can collaborate with peers from other regions or even countries, exposing them to a variety of approaches to mathematical problem-solving. Exposure to diverse perspectives broadens students' cognitive horizons and encourages the processes of argumentation, negotiation of meaning, and co-construction of knowledge. All of these serve as essential foundations for deep learning in mathematics.

Application Examples

a. **Problem-solving discussions on Padlet.** Students upload solutions to open-ended questions, then provide comments or alternative strategies to their classmates' answers.

b. **Google Classroom for project-based learning**. Teachers divide students into cross-grade/regional groups to work on math projects, such as analyzing local statistical data.

c. **Microsoft Teams for synchronous learning**. The teacher holds breakout rooms for small group discussions, where each group must present their solutions.

5. Curriculum Strategies and Teacher Training to Support Digital Literacy

The success of technology integration to support deep learning in mathematics instruction depends heavily on teacher preparedness and curriculum design. Technologies like AI, AR, VR, and IoT offer enormous potential, but without adequate teacher competency and a relevant curriculum, their use will tend to be shallow or even counterproductive.

In terms of teacher competency, training to master interactive media, digital simulations, and learning analytics is a key factor. Sugandi et al. (2025) emphasized that the quality of educational technology implementation, particularly AI-based technology, is largely determined by teachers' ability to operate and integrate it into pedagogical strategies. Skilled teachers can utilize technology not merely as a presentation tool, but also as a facilitator for conceptual exploration, critical reflection, and problem-solving.

However, Muvid (2024) found that teacher resistance often arises from the additional workload, both in preparing digital materials and analyzing learning outcome data. Therefore, technology integration needs to be accompanied by incentive strategies and institutional support, for example, by providing dedicated time for professional development, rewarding innovation, and providing adequate technical support. This will create a more conducive ecosystem for teachers to adapt to change.

From a curriculum perspective, technology integration should be directed at developing 21st-century skills such as critical, creative, collaborative, and communicative thinking Arsyad et al. (2025); Fatmawaty (2024); Maulida et al. (2024) studies have shown that utilizing AR, VR, and IoT in mathematics learning contexts can create immersive learning experiences. For example, students can explore geometric shapes through VR, connect IoT sensors with real-world statistical data, or utilize AR to understand geometric transformations. With a purposeful curriculum design, these technologies not only increase student engagement but also strengthen deep learning processes that focus on deep understanding and meaningful application.

Thus, the integration of technology in mathematics education requires two complementary aspects: (1) teachers who are competently prepared, motivated, and institutionally supported; and (2) a curriculum that is able to guide the use of technology to develop conceptual skills as well as 21st-century competencies.

Application Examples

a. **Direct practice-based teacher training.** Teachers are trained to use AI learning analytics to identify student difficulties and then design data-driven interventions.

b. **Digital project-based curriculum.** Students develop IoT-based projects, such as calculating household electricity consumption, to learn mathematical concepts in a real-world context.

c. **Inter-school collaboration.** Educational institutions provide online forums for teachers to share best practices for AR/VR integration in mathematics learning.

CONCLUSION

Technology integration in mathematics learning has proven to have significant potential for strengthening deep learning, particularly through the use of interactive media, AR/VR, AI, and IoT, which can provide a more immersive, critical, creative, and collaborative learning experience. However, successful implementation is largely determined by teacher readiness and adaptive curriculum design. Continuous teacher training is an urgent need, as competence in managing educational technology will determine the quality of learning. Furthermore, teacher resistance due to additional workloads needs to be addressed through the provision of adequate incentives and institutional support.

Therefore, it is recommended that educational institutions design structured teacher training programs focused on mastering digital technologies for deep learning. Curricula should also be designed to be more flexible and forward-thinking, integrating modern technology with 21st-century learning objectives. The government, schools, and other stakeholders should collaborate to provide facilities, regulations, and an ecosystem that supports technology-based learning innovations to ensure optimal and sustainable implementation of deep learning.

REFERENCE

Abdillah, Syaharuddin, Mandailina, V., & Mehmood, S. (2024). The Role of Mathematics in Machine Learning for Disease Prediction: An In-Depth Review in the Healthcare Domain. *Advance Sustainable Science, Engineering and Technology*, *6*(4), 1–11. https://doi.org/10.26877/asset.v6i4.845

Arsyad, M., Azizi, M. A., Al Iklhas, Leuwol, N. V., Nasyanovariani, D. F., & Manuhutu, A. (2025). Pemanfaatan AI dan Deep Learning dalam Pembelajaran STEAM Berbasis Outcome-Based Education. *Jurnal Edu Research Indonesian Institute For Corporate Learning And Studies (IICLS)*, *6*(1), 1180–1190. https://doi.org/10.47827/jer.v6i1.638

Awang, L. A., Yusop, F. D., & Danaee, M. (2025). Current practices and future direction of artificial intelligence in mathematics education: A systematic review. *International Electronic Journal of Mathematics Education* , *20*(2). https://doi.org/10.29333/iejme/16006

Dhani, S. R., Nasution, M. D., & Irvan, I. (2022). Penggunaan desmos dalam pembelajaran matematika materi program linier sebagai sarana meningkatkan kemampuan siswa. *AKSIOMA : Jurnal Matematika Dan Pendidikan Matematika*, *13*(2), 237–247. https://doi.org/10.26877/aks.v13i2.11227

Efendi, E., & Asrizal. (2025). Research Trends and Opportunities in Integrating Augmented Reality and Deep Learning into Science Education: A Bibliometric Analysis. *Jurnal Penelitian Pendidikan IPA*, *11*(7), 1–11. https://doi.org/10.29303/jppipa.v11i7.11988

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

Fathurrahman, F., & Fitrah, M. (2023). Software Geogebra Pada Pembelajaran Matematika: Studi Literatur. *Jurnal Ilmiah Matematika Realistik*. https://jim.teknokrat.ac.id/index.php/pendidikanmatematika/article/view/2497

Fatmawaty, F. (2024). Deep Learning : Sebuah Pendekatan untuk Pembelajaran Bermakna. *Harmoni Pendidikan: Jurnal Ilmu Pendidikan*, *1*(1), 71–85.

Fitriani, A., & Santiani. (2025). Analisis Literatur: Pendekatan Pembelajaran Deep Learning dalam Pendidikan. *Jurnal Ilmiah Nusantara (JINU)*, *2*(3), 50–57. https://doi.org/10.61722/jinu.v2i3.4357

Hamzah, F., Abdullah, A. H., & Ma, W. (2024). Advancing Education through Technology Integration, Innovative Pedagogies and Emerging Trends: A Systematic Literature Review. *Journal of*

Advanced Research in Applied Sciences and Engineering Technology, *41*(1), 44–63. https://doi.org/10.37934/araset.41.1.4463

Hanifah, U., Budayasa, I. K., & Sulaiman, R. (2025). Technology, pedagogy, and content knowledge in mathematics education: a systematic literature review. *Journal of Education and Learning*, *19*(1), 579–586. https://doi.org/10.11591/edulearn.v19i1.21816

Hayati, R. (2025). Peran Deep Learning Dalam Meningkatkan Keterampilan Pemecahan Masalah Siswa. *Jurnal Pendidik Indonesia*, *6*(1), 29–39.

Hidayat, A., & Firmanti, P. (2024). Navigating the tech frontier: a systematic review of technology integration in mathematics education. *Cogent Education*, *11*(1). https://doi.org/10.1080/2331186X.2024.2373559

Hidayat, A. G., & Haryati, T. (2025). Analysis of Learning Effectiveness Using the Deep Learning Approach in Elementary Schools. *Kurikula : Jurnal Pendidikan*, *9*(2), 126–139. https://doi.org/10.56997/kurikula.v9i2.2083

Joseph, O. B., & Uzondu, N. C. (2024). Integrating AI and Machine Learning in STEM education: Challenges and opportunities. *Computer Science & IT Research Journal*, *5*(8), 1732–1750. https://doi.org/10.51594/csitrj.v5i8.1379

Maharani, L., Riyadi, A. R., & Maulida, N. (2025). DEEP LEARNING DALAM PEMBELAJARAN MATEMATIKA DI SD. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *6*(1), 147–155.

Mailani, E., Rarastika, N., Jannah, M., Heriani, N. A., & Zendrato, W. E. (2025). Pemanfaatan Strategi Deep Learning untuk Meningkatkan Pemahaman Konsep Matematika Dasar Siswa Sekolah Dasar: Studi Literatur. *JIIC: Jurnal Intelek Insan Cendikian*, *2*(6), 12349–12355. https://jicnusantara.com/index.php/jiic

Maulida, L., Nurossobah, P., Aura, B. A., Nengsih, E. D., & Rasilah, R. (2024). Improving The Effectiveness of Mathematics Learning Through Artificial Intelligence: Literature Review. *Journal of General Education and Humanities*, *3*(4), 323–338. https://doi.org/10.58421/gehu.v3i4.267

Mediana Jr, N. L., & Dio, R. V. (2025). Systematic Review on the Efficacy of Desmos Integration in Mathematics Education: Unveiling Impacts on Learning Outcomes and Pedagogical Strategies. *International Journal of Future Engineering Innovations*, *2*(4), 104–115. https://doi.org/10.54660/ijfei.2025.2.4.104-115

Mulyanto, A., Supriatna, N., Erawati, E. R., Heryati, T., & Mulyanah, U. (2025). Peningkatan Kualitas Belajar Melalui Kepemimpinan Pembelajaran Berbasis Deep Learning di SMPN 3 Margahayu. *Jurnal Pengabdian Masyarakat: Pemberdayaan, Inovasi Dan Perubahan*, *5*(3), 7–16. https://doi.org/10.59818/jpm.v5i3.1653

Muvid, M. B. (2024). Menelaah Wacana Kurikulum Deep Learning: Urgensi Dan Peranannya Dalam Menyiapkan Generasi Emas Indonesia. *Jurnal Pendidikan Dan Kebudayaan*, *3*(2), 80–93. https://doi.org/10.5281/zenodo.14403663

Nasution, A. U., Syahputra, E., & Ahyaningsih, F. (2022). … Model Pembelajaran Berbasis Matematika Realistik Berbantuan Geogebra untuk Meningkatkan Kemampuan Pemecahan Masalah Matematis Siswa SMP Al Azhar …. *... Jurnal Pendidikan Matematika*. https://j-cup.org/index.php/cendekia/article/view/1379

Novita Barokah, & Umi Mahmudah. (2025). Transformasi Pembelajaran Matematika SD Melalui Deep Learning: Strategi untuk Meningkatkan Motivasi dan Prestasi. *Bilangan : Jurnal Ilmiah Matematika, Kebumian Dan Angkasa*, *3*(3), 48–61. https://doi.org/10.62383/bilangan.v3i3.521

Putri, A. D., Juandi, D., & Turmudi. (2024). Realistic mathematics education and mathematical literacy: a meta-analysis conducted on studies in Indonesia. *Journal of Education and Learning*, *18*(4), 1468–1476. https://doi.org/10.11591/edulearn.v18i4.21650

Rafi, I., & Sabrina, N. (2019). Pengintegrasian TPACK dalam Pembelajaran Transformasi Geometri SMA untuk Mengembangkan Profesionalitas Guru Matematika. *SJME (Supremum Journal of Mathematics Education)*, *3*(1), 47–56. https://doi.org/10.35706/sjme.v3i1.1430

Rahayu, C., Setiani, W. R., Yulindra, D., & Azzahra, L. (2025). Pendidikan Matematika Realistik Indonesia dalam Pembelajaran Mendalam (Deep Learning): Tinjauan Literatur. *Jurnal Pendidikan Matematika Universitas Lampung*, *13*(1), 9–25. https://doi.org/10.23960/mtk/v13i1.pp9-25

Ratnasari, Nurvicalesti, N., & Wati, A. S. (2025). Implementasi Pembelajaran Mendalam terhadap KemampuanBerpikir Kritis Matematis Siswa. *Algoritma: Jurnal Matematika, Ilmu Pengetahuan Alam, Kebumian Dan Angkasa*, *3*(4), 43–50. https://journal.arimsi.or.id/index.php/Algoritma

Sugandi, A. ikin, Bernard, M., Hendriana, H., & Linda, L. (2025). Pelatihan penerapan deep learning terhadap pembelajaran Matematika pada guru-guru SMA di Kota Cimahi. *Abdimas Siliwangi*, *8*(2), 326–338. https://doi.org/10.22460/as.v8i2.27377

Tañola, M. D., & Lomibao, L. S. (2024). Understanding How Students Learn Mathematics: A Systematic Literature Review of Contemporary Learning Strategies in Mathematics Education Post-2020. *Journal of Innovations in Teaching and Learning*, *4*(1), 66–75. https://doi.org/10.12691/jitl-4-1-11

Wijaya, M. (2025). Kurikulum Deep Learning di Indonesia; Sebuah Harapan Baru. *Jurnal Ilmiah Pendidikan Scholastic*, *9*(1), 10–15. https://doi.org/10.36057/jips.v9i1.713

Yanuar, A., Fazar, W., Siswanto, D., Feriyadi, D., & Dinoto, M. (2025). Matematika Berbasis Pendekatan Deep Learning Bagi Guru Sma / Smk. *Jurnal Abdipura*, *1*, 62–73.

Zhilmagambetova, R. (2023). The Role of Adaptive Personalized Technologies in the Learning Process: Stepik as a Tool for Teaching Mathematics. *International Journal of Virtual and Personal Learning Environments*, *13*(1). https://doi.org/10.4018/IJVPLE.324079

Zou, Y., Kuek, F., Feng, W., & Cheng, X. (2025). Digital learning in the 21st century: trends, challenges, and innovations in technology integration. *Frontiers in Education*, *10*. https://doi.org/10.3389/feduc.2025.1562391