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Research Article

Research Trends on Deep Learning for Mathematics Learning in Scopus Database: Concept Map & Emerging Themes Using Scopus AI

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Research Trends on Deep Learning for Mathematics Learning in Scopus Database: Concept Map & Emerging Themes Using Scopus AI

Abstract. This paper aims to explore the concepts and themes emerging in the literature related to "Deep Learning in Mathematics Learning" in order to understand the direction of development and

current trends in the field. To achieve this goal, the study uses the Automatic Systematic Literature Review (SLR) method with the help of Scopus AI, which allows for the automatic identification of concepts and themes through the visualization of concept maps and emerging themes. The database selection focused solely on Scopus due to its high reputation and extensive coverage of high-quality international journals. The keyword used is "deep learning in mathematics learning" with a publication time limit from 2003 to 2025, thus covering early developments to the latest trends. This approach allows for systematic and efficient literature mapping without having to manually review all documents. The analysis reveals that the topic of "Deep Learning in Mathematics Learning" encompasses several emerging themes, including student performance prediction, AI integration in mathematics education, and the adoption of innovative pedagogical practices. Based on the concept map visualization, three main research directions are identified: Learning Environment, Techniques, and Applications. The theme of student performance prediction highlights the use of neural network models such as CNNs and LSTMs to analyze key factors influencing academic outcomes. Meanwhile, AI integration focuses on the development of adaptive learning platforms that personalize instruction and enhance learning effectiveness. Innovative pedagogical practices, including the use of extended reality and machine learning, aim to create immersive and interactive learning experiences. Overall, these findings underscore the significant potential of deep learning to transform mathematics education through intelligent, adaptive, and student-centered approaches.
Keywords: Deep Learning, Mathematics Learning, Scopus AI

Abstrak. Makalah ini bertujuan untuk mengeksplorasi konsep dan tema-tema yang muncul dalam literatur terkait "Deep Learning dalam Pembelajaran Matematika" guna memahami arah perkembangan dan tren terkini dalam bidang tersebut. Untuk mencapai tujuan ini, penelitian menggunakan metode *Automatic Systematic Literature Review* (SLR) dengan bantuan Scopus AI, yang memungkinkan identifikasi konsep dan tema secara otomatis melalui visualisasi *concept map* dan *emerging themes*. Pemilihan basis data difokuskan hanya pada Scopus karena reputasinya yang tinggi serta cakupan jurnal internasional berkualitas yang luas. Kata kunci yang digunakan adalah "deep learning in mathematics learning" dengan batasan waktu publikasi dari tahun 2003 hingga 2025, sehingga mencakup perkembangan awal hingga tren terkini. Pendekatan ini memungkinkan pemetaan literatur secara sistematis dan efisien tanpa harus menelaah seluruh dokumen secara manual. Hasil analisis menunjukkan bahwa topik "Deep Learning dalam Pembelajaran Matematika" mencakup beberapa *emerging themes*, antara lain prediksi kinerja siswa, integrasi AI dalam pendidikan matematika, dan penerapan praktik pedagogis inovatif. Berdasarkan visualisasi *concept map*, terdapat tiga arah utama penelitian yang teridentifikasi, yaitu *Learning Environment*, *Techniques*, dan *Applications*. Tema prediksi kinerja siswa menyoroti penggunaan model jaringan saraf seperti CNN dan LSTM untuk menganalisis faktor-faktor utama yang memengaruhi hasil belajar. Sementara itu, integrasi AI berfokus pada pengembangan platform pembelajaran adaptif yang mempersonalisasi instruksi dan meningkatkan efektivitas pembelajaran. Praktik pedagogis inovatif, termasuk penggunaan extended reality dan machine learning, bertujuan menciptakan pengalaman belajar yang imersif dan interaktif. Secara keseluruhan, temuan ini menegaskan potensi besar deep learning dalam mentransformasi pendidikan matematika melalui pendekatan yang cerdas, adaptif, dan berpusat pada siswa.

Kata Kunci: Pembelajaran Mendalam, Pembelajaran Matematika, Scopus AI

INTRODUCTION

Education is a structured process aimed at developing individuals to their fullest potential in terms of knowledge, skills, and character (Ariawan et al., 2024; Retnawati & Hidayat, 2025; Wahyuni et al., 2024). It provides a strong foundation for critical thinking, creativity, and the ability to face real-world challenges. The significance of education goes beyond the transfer of knowledge, it also involves shaping moral values and personal integrity (Nabilah et al., 2025; Zafrullah et al., 2025). In the 21st century, education is expected to be more adaptive to technological advancements and global demands (Andrian et al., 2020; Ramadhani et al., 2024; Zafrullah & Ramadhani, 2024). The concept of education now emphasizes active learning, collaboration, and problem-solving approaches (Hamdi et al., 2024; Istiawanto et al., 2024). This shift encourages innovative teaching methods that support students' holistic development. One key area where adaptive and relevant educational practices are essential is in the integration of technology-based learning (Izzulhaq et al., 2024; Ramadhani & Retnawati, 2024). A subject that particularly requires conceptual understanding, logical reasoning, and analytical thinking is mathematics learning.

Mathematics learning is a structured process that focuses on developing students' ability to understand concepts, solve problems, and think logically (Hakim & Angga, 2023; Wahyuni et al., 2025). It plays a crucial role in building analytical skills and fostering a systematic way of thinking that can be applied in various aspects of life. Mathematics learning provides opportunities for students to explore patterns, relationships, and structures through reasoning and evidence. With the integration of technology, mathematics education has evolved to include more interactive and personalized approaches (Sharma, 2024; Susanto et al., 2023). These approaches aim to enhance student engagement and adapt to individual learning needs. In recent years, innovative methods such as intelligent tutoring systems and data-driven instruction have been introduced to support learning efficiency (Alfarra et al., 2024). The use of artificial intelligence and advanced computational models in education is becoming increasingly important. One of the emerging approaches that offers great potential for transforming mathematics education is deep learning.

Deep learning is a learning approach that emphasizes in-depth conceptual understanding, rather than simply memorizing or mastering mechanical procedures (Budhiarti et al., 2025). This approach encourages students to connect existing knowledge with new information, creating meaningful understanding. In the context of mathematics learning, deep learning helps students develop critical thinking skills, problem-solving skills, and the application of concepts in real-life situations (Khalabuzar & Shymanovych, 2024). This process involves active

reflection, exploration, and knowledge construction by students. Teachers act as facilitators, creating challenging and contextual learning environments to encourage students to learn more deeply (Assen & Otting, 2022). Therefore, research on deep learning is receiving increasing attention.

Several previous studies have highlighted the importance of implementing deep learning in educational contexts, ranging from strengthening conceptual understanding, its use in processing educational time series data, to developing recommendation systems for personalized learning (Akmal et al., 2025; Junus & Brophy, 2023). Deep learning has been proven to support improving the quality of learning through big data analysis, predicting student achievement, and developing learning materials tailored to individual needs. Furthermore, this approach enables the integration of artificial intelligence technology into the teaching and learning process in a more adaptive and efficient manner. However, in-depth exploration of new themes and relationships between concepts is still limited, especially in the context of mathematics learning that demands abstract understanding and logical application. Previous studies also show that conventional SLR approaches tend to require significant time and resources to identify relevant literature patterns. Therefore, the analysis in this study utilizes Scopus AI as an exploratory tool to identify concept maps and emerging themes in deep learning studies on mathematics learning, in an effort to provide a more efficient, structured, and contextual literature synthesis.

METHOD

This research method uses the Automatic Systematic Literature Review (SLR) approach with the help of Scopus AI to explore concepts and themes that emerge in the literature related to "Deep Learning in Mathematics Learning". The database selection focused solely on Scopus because it is one of the reputable scientific databases that includes international journals with broad coverage and maintained quality. The keyword used was "deep learning in mathematics learning", which was entered directly into the Scopus AI feature to obtain automatic exploration results in the form of concept maps and emerging themes. The time limit of the analyzed literature was from 2003 to 2025, to cover the initial developments to the latest trends in the application of deep learning in the field of mathematics education.

The primary focus of the analysis process is the visualization of the concept map, which displays the relationships between key topics and identifies emerging themes that developed over a specified timeframe. Scopus AI is used as a tool to accelerate the process of theme identification and literature mapping automatically, eliminating the need to review all documents individually. This approach allows researchers to gain a systematic and structured understanding of how deep learning topics are applied in mathematics learning, as well as emerging trends.

RESULTS AND DISCUSSION

Emerging Themes

There are several emerging themes recommended by Scopus AI, namely as follows.

Predicting Student Performance using Deep Learning

Progress in the area of predicting student performance using deep learning has been significant. Figure 1 shows a total of 56 papers discussing this topic from August 2023 to August 2025.

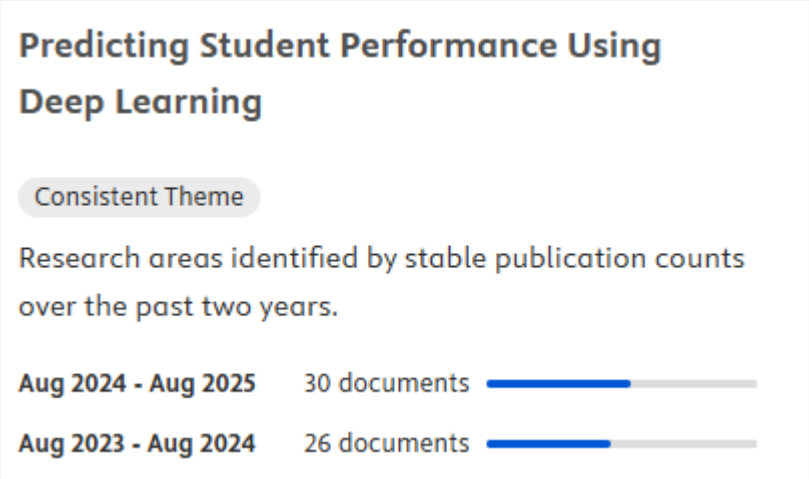

Figure 1. Emerging Theme in Predicting Student Performance using Deep Learning

The use of deep learning techniques to predict student performance remains a consistent and significant focus in educational research. This theme centers on leveraging advanced neural networks, such as Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) models, to analyze various factors influencing student outcomes. These factors include emotional wellbeing, online learning activities, and academic behaviors captured through digital learning platforms.

The consistent presence of this theme across studies highlights its crucial role in enhancing educational systems. Deep learning models, with their ability to detect complex patterns, enable early interventions that support student success. Additionally, this approach allows for the development of more personalized and adaptive learning strategies based on accurate and real-time data, ultimately improving the quality and effectiveness of education.

AI Integration in Mathematics Education

Progress in the area of AI integration in mathematics education has been significant. Figure 2 shows a total of 46 papers discussing this topic from August 2023 to August 2025.

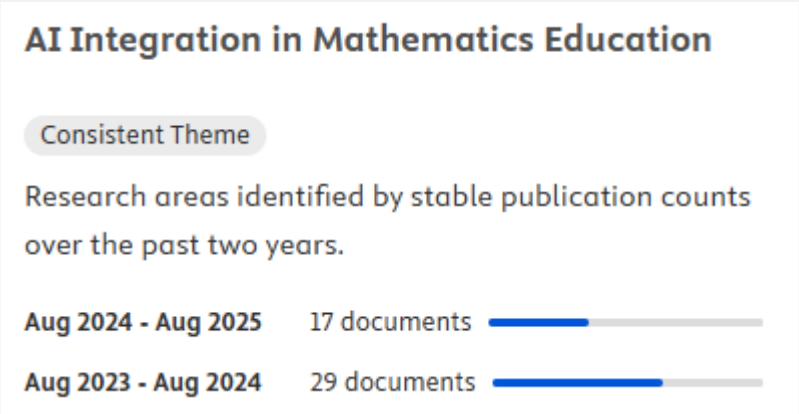

Figure 2. Emerging Theme in AI Integration in Mathematics Education

The integration of artificial intelligence (AI) in mathematics education has remained a major area of interest in recent years. This includes the development of AI-powered learning platforms, personalized learning systems, and adaptive technologies aimed at improving mathematics instruction and student engagement. These tools allow the learning process to be tailored to individual student needs and capabilities, making instruction more effective and relevant. AI also enables educators to detect learning difficulties early and provide timely interventions. As a result, AI-based approaches present a promising alternative to traditional mathematics teaching methods.

The continued focus on this theme reflects the strong potential of AI to transform mathematics education. AI contributes not only to content delivery but also to learning analytics that support better pedagogical decision-making. These technologies promote more interactive, dynamic, and data-driven learning experiences. Furthermore, AI facilitates the creation of personalized learning paths, enhancing student motivation and academic outcomes. Therefore, integrating AI into mathematics instruction offers a long-term strategy for improving both the quality and accessibility of education.

Innovative Pedagogical Practices in Mathematics Education

Progress in the area of innovative pedagogical practices in mathematics education has been significant. Figure 3 shows a total of 46 papers discussing this topic from August 2023 to August 2025.

Figure 3. Emerging Theme in Innovative Pedagogical Practices in Mathematics Education

There is growing interest in innovative pedagogical practices in mathematics education, particularly those that integrate extended reality (XR) and machine learning. This theme investigates how technology can be leveraged to create immersive and interactive learning environments that help students better grasp abstract mathematical concepts. Technologies such as augmented reality (AR) and virtual reality (VR) offer dynamic, visual representations that allow students to directly engage with mathematical content. These interactions enhance the learning experience by increasing student motivation and classroom engagement. As a result, XR acts as a bridge between mathematical theory and real-world application.

On the other hand, machine learning plays a vital role in enabling adaptive learning systems that adjust content and instructional methods based on individual student needs. By analyzing student performance data, these systems can recommend more effective and personalized learning strategies. The combination of XR and machine learning offers a powerful framework for designing intelligent, responsive mathematics instruction. The growing attention to this theme reflects a shift from traditional teaching methods toward more technology-enhanced, student-centered approaches. This marks a significant step forward in transforming mathematics education in the digital age.

Concept Map

Concept maps in Scopus AI aim to visualize the relationships between key topics within a research field. These maps help researchers systematically and efficiently understand the structure, interrelationships, and development of key themes.

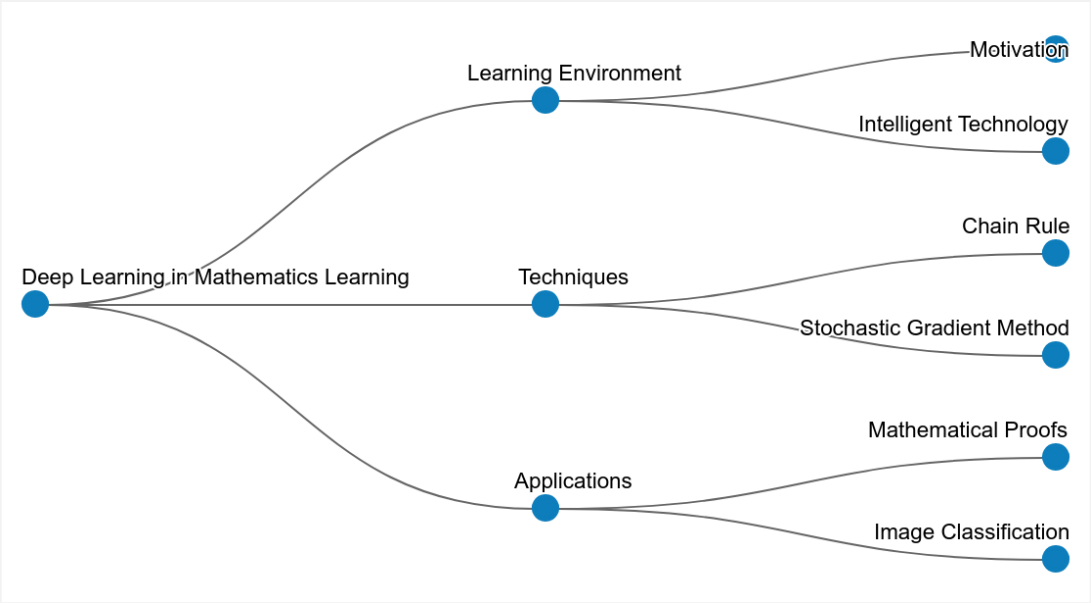

Figure 4. Concept Map About Deep Learning in Mathematics Learning

Based on the visualization of the concept map from Scopus AI, the main topic of "Deep Learning in Mathematics Learning" is divided into three major branches: Learning Environment, Techniques, and Applications. These branches reflect the main direction of research development in the application of deep learning to mathematics learning. The Learning Environment section shows a focus on creating adaptive and intelligent learning environments through the use of technology. This indicates the need to design learning systems that can adapt to individual student needs.

The Learning Environment subtheme, Motivation and Intelligent Technology, demonstrates that learning motivation and intelligent technology are two crucial components in creating an effective mathematics learning ecosystem. Deep learning supports the creation of a learning environment that motivates students through a more personalized and contextual approach. Meanwhile, the integration of intelligent technologies such as recommendation systems or virtual tutors allows students to receive timely assistance tailored to their needs. This approach supports self-directed learning strategies and increases student engagement in the learning process.

The Techniques branch refers to technical approaches to deep learning applications, with two main subthemes: Chain Rule and Stochastic Gradient Method. Both are fundamental concepts in machine learning algorithms applied to solve problems in mathematics. Mastery of these techniques is crucial for designing efficient and accurate AI-based learning models. Therefore, research in this theme often focuses on model development and performance testing using complex mathematical datasets.

Finally, the Applications section focuses on the concrete applications of deep learning in mathematical contexts, including mathematical proofs and image classification. Using deep learning to aid mathematical proofs opens up new opportunities for simplifying abstract concepts. Meanwhile, image classification can be used to recognize mathematical shapes or symbols, which is beneficial for visual learning and the use of interactive digital media. Thus, research in this area has great potential to enrich mathematics teaching methods and open up new, more creative and applicable approaches.

CONCLUSION

The analysis reveals that the topic of "Deep Learning in Mathematics Learning" encompasses several emerging themes, including student performance prediction, AI integration in mathematics education, and the adoption of innovative pedagogical practices. Based on the concept map visualization, three main research directions are identified: Learning Environment, Techniques, and Applications. The theme of student performance prediction highlights the use of neural network models such as CNNs and LSTMs to analyze key factors influencing academic outcomes. Meanwhile, AI integration focuses on the development of adaptive learning platforms that personalize instruction and enhance learning effectiveness. Innovative pedagogical practices, including the use of extended reality and machine learning, aim to create immersive and interactive learning experiences. Overall, these findings underscore the significant potential of deep learning to transform mathematics education through intelligent, adaptive, and student-centered approaches.

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