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RESEARCH TRENDS ON DEEP LEARNING APPROACHES IN EDUCATION: A BIBLIOMETRIC ANALYSIS

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Abstract: The deep learning approach in education, understood as meaningful, mindful, and joyful learning that cultivates higher-order thinking skills (HOTS), has increasingly attracted scholarly and policy attention. Unlike artificial intelligence-based deep learning, this pedagogical approach emphasizes student-centered learning, critical reasoning, creativity, and the integration of knowledge into real-life contexts. This study systematically maps research trends on deep learning approaches in education using bibliometric analysis. A dataset of 1,682 open-access documents (articles and conference papers) published between 2020 and 2025 was analyzed to identify patterns of publication growth, leading sources and affiliations, authorship collaboration, as well as thematic hotspots and emerging directions. The findings reveal a consistent upward trajectory in publication outputs with an annual growth rate of 22.98%, dominated by contributions from Asian institutions, particularly China, alongside notable global collaborations. Thematic analysis highlights strong intersections between deep learning approaches and areas such as engineering education, digital pedagogy, and curriculum innovation, while emerging topics point to adaptive learning, contrastive learning, and cognitive processes like short-term memory. These results suggest that the field is shifting from foundational exploration toward more integrative and applied pedagogical models. This bibliometric study provides new insights for educators, researchers, and policymakers to anticipate future developments and strengthen the role of deep learning approaches in fostering transformative and equitable educational practices.

Keywords: Deep Learning Approach; Research Trends; Bibliometric Analysis.

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INTRODUCTION

The deep learning approach in education is understood as a learning approach that emphasizes in-depth conceptual understanding, the interconnectedness of knowledge, and its application in real life (Akmal et al., 2025; Rissi & Sinaga, 2025). Unlike surface learning, which tends to be oriented toward memorization and reproduction of information, the deep learning approach encourages students to construct meaning through reflective, critical, and creative processes (Perrotta & Selwyn, 2020). In this context, the teacher acts as a facilitator who creates motivating learning experiences, while students are positioned as active actors in constructing their own understanding. Thus, this approach emphasizes not only cognitive aspects but also affective and social aspects.

The three main principles of the deep learning approach are mindful learning, meaningful learning, and joyful learning (Andayanie et al., 2025; Feriyanto & Anjariyah, 2024; Taqiyya et al., 2025). Mindful learning means the learning process takes place with full awareness, where the teacher values the unique experiences and potential of each student. Meaningful learning emphasizes the importance of material relevant to students' lives, so that knowledge is not merely abstract information but becomes a useful resource. Joyful learning creates a pleasant learning atmosphere that fosters students' curiosity and intrinsic motivation. These three principles form a pedagogical framework oriented towards the humanization of education, ultimately improving the quality of interactions between teachers, students, and learning materials.

In addition to these principles, the deep learning approach is closely related to the development of higher-order thinking skills (HOTS), such as critical, analytical, evaluative, and creative thinking (Chosya & Takiddin, 2025). HOTS are considered essential competencies in the 21st century, where students are faced with complex global issues that require adaptive problem-solving skills (Apino & Retnawati, 2018). In this approach, students not only answer "what" questions but also "why" and "how" questions, while being

encouraged to create new solutions. Thus, the deep learning approach is not only a learning strategy but also a competency development framework relevant to the demands of globalization, digitalization, and sustainability.

In a global context, the deep learning approach aligns with UNESCO's initiatives on Education for Sustainable Development (ESD) and Global Citizenship Education (GCED), which encourage transformative, participatory, and sustainability-oriented learning (Kamaruldzaman et al., 2025). Many developed and developing countries have integrated deep learning principles into their curricula to produce adaptive and innovative lifelong learners (Zebua, 2025). Furthermore, international standards such as the 21st Century Skills Framework emphasize the importance of collaboration, communication, creativity, and critical thinking skills, which align with the essence of the deep learning approach (Thornhill-Miller et al., 2023). This confirms that this approach is not a local phenomenon, but rather part of a global educational movement.

Indonesia has also begun mainstreaming the deep learning approach in education policy (Prihantoro et al., 2025). Through the Pancasila Student Profile concept, the government emphasizes holistic, character-based learning that is relevant to the challenges of the times (Ratnawati et al., 2024). The Minister of Education emphasized the importance of implementing mindful, meaningful, and joyful learning to improve the quality of national education. This implementation is expected to address the low literacy, numeracy, and HOTS scores of Indonesian students, as recorded in international assessments such as PISA. Thus, the deep learning approach is seen as a strategic instrument in education reform to produce a generation that is intelligent, competitive, and imbued with national character (Zebua, 2025).

However, there is a significant gap between policy discourse and practice. Many teachers remain trapped in rote-based and exam-oriented learning practices, resulting in suboptimal implementation of the deep learning approach (Wibawa, 2023). Furthermore, academic research systematically mapping the development and effectiveness of this approach remains limited, both nationally and internationally. This gap creates an urgent need for a comprehensive study that can describe research trends, the scientific landscape, and future directions for research on deep learning approaches in education. Bibliometric analysis offers a significant contribution to addressing this need, as it can identify publication patterns, key themes, and research opportunities that can strengthen educational practice in an era of global transformation (Huang et al., 2020).

Against this backdrop, this study aims to systematically map research trends on deep learning approaches in education through bibliometric analysis. Specifically, this study seeks to identify publication growth patterns, contributions by dominant authors, institutions, and countries, and map key themes and the direction of research development. Accordingly, the research questions focused on: (1) how publications on deep learning approaches in education have evolved over time; (2) which authors, institutions, and countries have made the greatest contributions to this field; (3) what research themes and clusters have emerged and become the focus of attention (hotspots); and (4) what research directions can be derived from these trends. Through this focus, the research is expected to contribute to the development of educational practices and enrich the academic literature on the application of deep learning approaches in global and national contexts.

METHODS

This study uses bibliometric analysis methods to map and evaluate research trends related to deep learning approaches in education (Chang et al., 2023; Chen et al., 2021; Su et al., 2021). The Scopus database was chosen as the primary source due to its broad multidisciplinary coverage, rigorous indexing quality, and standardized metadata, ensuring data reliability (Pranckutė, 2021). The search strategy was systematically designed with more specific and relevant keywords, such as "Deep Learning Approaches in Education." These keywords were run using Boolean operators on titles, abstracts, and keywords to broaden the scope of search results while maintaining relevance.

The initial data collection process resulted in 6,846 documents indexed in Scopus. However, to maintain the research focus, restrictions were applied based on the publication period from 2020 to 2025, subject areas relevant to education, and document types, which included only journal articles and

conference proceedings. Additionally, additional filters were applied to limit the publications to open access publications, with the aim of increasing transparency and accessibility of research results. After the filtering process, the number of relevant documents was reduced to 1,682, which then served as the primary dataset for further analysis.

The analysis procedure was conducted systematically using RStudio software with the Bibliometrix package. Publication metadata obtained from Scopus was exported in CSV format and then analyzed using two main approaches: performance analysis and science mapping. Performance analysis was used to evaluate annual publication trends, citation rates, and contributions by authors, institutions, and countries. Meanwhile, science mapping focused on keyword distribution, collaboration networks between authors and institutions, and the thematic evolution of research related to deep learning approaches in education.

Data visualization was performed using the Biblioshiny feature integrated with Bibliometrix to generate publication trend graphs, international collaboration maps, and thematic evolution maps. This approach allows for a more comprehensive interpretation of research dynamics over the past decade. In this way, this study not only presents a quantitative mapping of research productivity and impact, but also provides a conceptual overview of the direction of development of deep learning approaches in the field of education, while identifying research gaps that can be further explored in the future.

RESULT AND DISCUSSION

A bibliometric analysis of 1,682 documents published between 2020 and 2025 shows significant dynamics in research on deep learning approaches in education. These publications are spread across 570 sources (journals, proceedings, and others), with an annual growth rate of 22.98%, reflecting the increasing interest and relevance of this topic in the academic realm. The average document age is relatively young (1.8 years), indicating that the related studies are still relatively new and continue to develop, with an average of 6,424 citations per document, indicating a fairly broad scientific influence. In terms of content, this study generated 8,109 Keywords Plus keywords and 10,900 author keywords, demonstrating the diversity of topic focuses and research approaches used. A total of 8,457 authors were involved in these publications, with a high level of collaboration indicated by an average of 10.6 authors per document and a proportion of international collaboration of 14.74%. The document types are dominated by articles (772 documents) and conference proceedings (910 documents), demonstrating a balance between knowledge dissemination through reputable scientific publications and global academic forums. These data characteristics provide an initial overview of the development of research on deep learning approaches in education and serve as a basis for further analysis of publication patterns, collaborations, and thematic focus. The results of the bibliometric analysis using RStudio are as follows:

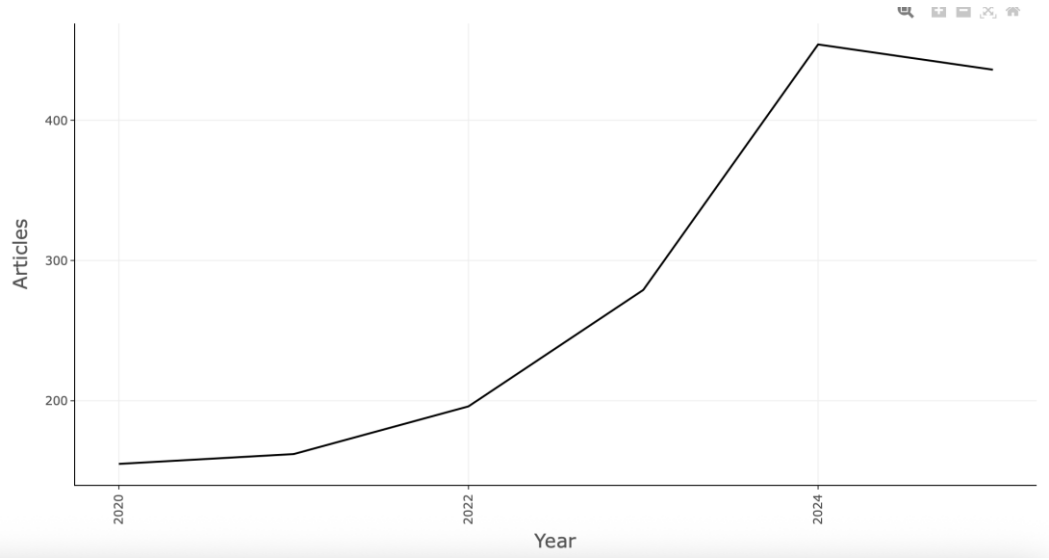

Figure 1. Annual Scientific Production

Annual publication trends show a consistent increase in research on deep learning approaches in education throughout the 2020–2025 period. In 2020, 155 articles were published, then steadily grew to 162 articles in 2021 and 196 articles in 2022. A significant spike occurred in 2023 with 279 articles, and a peak in 2024 with 454 articles, demonstrating accelerated interest and relevance of this topic within the academic community. Although the number of publications decreased slightly in 2025 to 436 articles, this figure remains significantly higher than at the beginning of the study period, indicating that the study of deep learning approaches in education is still in its growth phase and continues to be a significant global concern.

The significant surge after 2022 reflects a shift in research interest from simply applying computational technology to exploring more integrated deep learning-based pedagogies (Weng et al., 2023). This aligns with the global push to leverage artificial intelligence (AI) technology to enrich digital learning and strengthen learning strategies oriented toward 21st-century skills, particularly Higher Order Thinking Skills (HOTS) (Dibek et al., 2025). These data indicate that research is not only increasing quantitatively but also developing substantively toward utilizing deep learning for educational transformation. After presenting annual publication trends, the next analysis focused on identifying the most relevant publication sources, as shown in Figure 2.

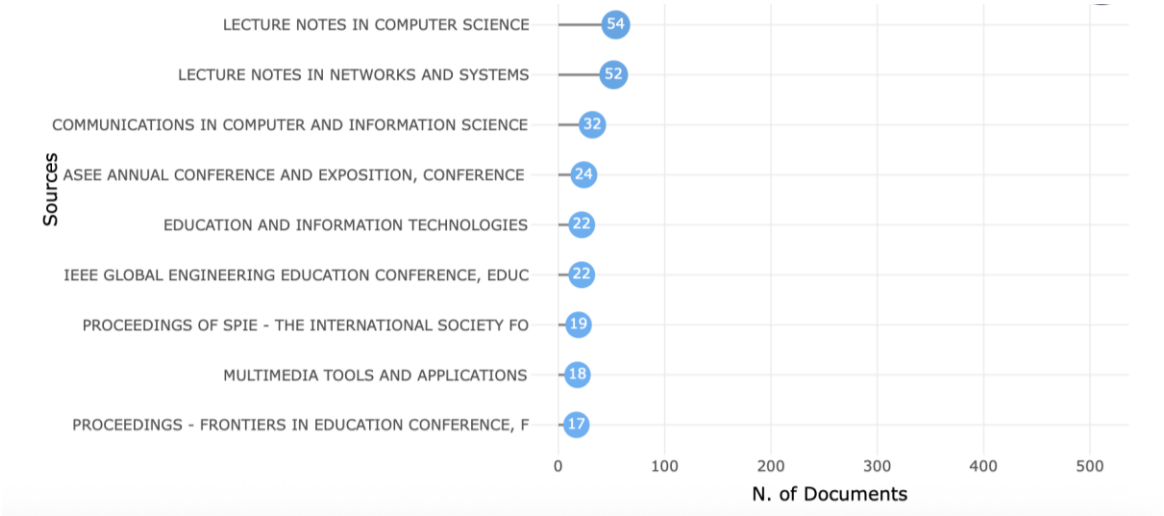

Figure 2. Most Relevant Sources

An analysis of publication sources shows that research on deep learning approaches in education appears most frequently in international conference proceedings, particularly Lecture Notes in Computer Science (54 articles) and Lecture Notes in Networks and Systems (52 articles). Furthermore, significant contributions came from Communications in Computer and Information Science (32 articles) and the ASEE Annual Conference and Exposition (24 articles), underscoring the crucial role of global academic forums in disseminating this topic. In the journal realm, Education and Information Technologies and IEEE EDUCON each produced 22 articles, followed by publications in Proceedings of SPIE (19 articles), Multimedia Tools and Applications (18 articles), and Frontiers in Education Conference (FIE) (17 articles). These findings demonstrate that deep learning research is not solely focused on information technology but also encompasses the contexts of media, multimedia, and pedagogical innovation. The dominance of proceedings over scholarly journals suggests that the topic of deep learning in education is still in its early, innovative exploration phase, but not yet fully established in the literature of reputable journals (Guan et al., 2020). However, journals such as Education and Information Technologies are beginning to play a role in consolidating more applicable and tested research. This opens up opportunities for more in-depth and systematic research to strengthen academic contributions in highly indexed journals. After reviewing the most relevant publication sources, the next analysis focused on the institutions or affiliations that contributed the most, as shown in Figure 3.

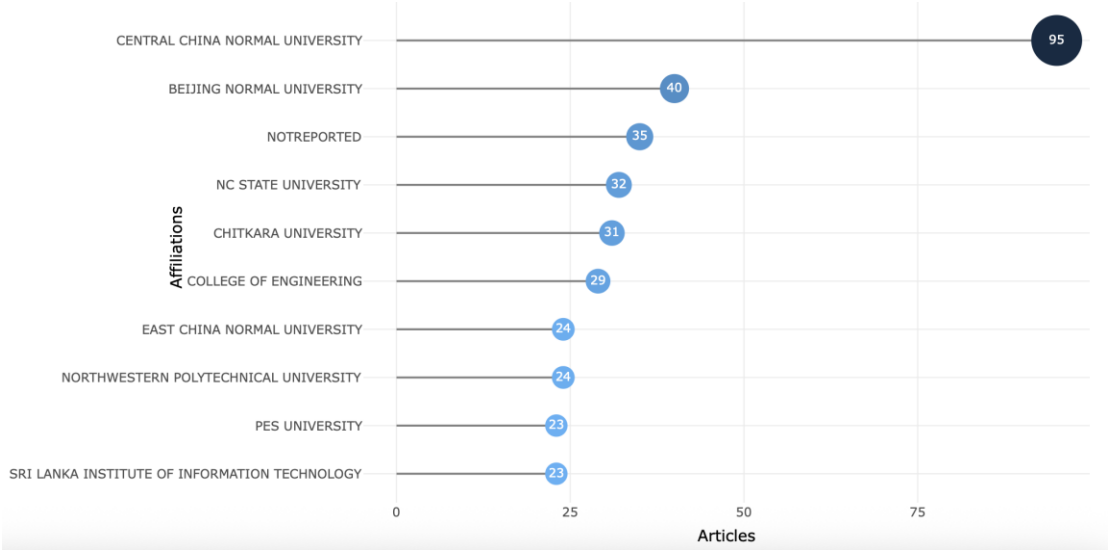

Figure 3. Most Relevant Affiliations

Analysis of author affiliations shows that the largest contribution to publications related to deep learning approaches in education came from Central China Normal University with 95 articles, followed by Beijing Normal University with 40 articles. This confirms the dominance of Chinese higher education institutions in this field. Contributions also came from institutions outside China, such as NC State University in the United States (32 articles), Chitkara University in India (31 articles), and the College of Engineering (29 articles), demonstrating the close relationship between engineering and the development of deep learning for education. Several other universities, such as East China Normal University, Northwestern Polytechnical University, PES University, and the Sri Lanka Institute of Information Technology, also made significant contributions, indicating that this topic has attracted attention across countries and disciplines.

The concentration of research at Chinese universities, particularly Central China Normal University and Beijing Normal University, aligns with the global trend that positions China as a major hub for AI and deep learning research (Gao et al., 2019). Although institutions from India, Sri Lanka, and the United States also actively contribute, the level of international collaboration remains relatively low (14.74%). This situation demonstrates the need to strengthen cross-national research networks to enrich perspectives and expand the application of deep learning in education, particularly in developing countries like Indonesia. After identifying the most relevant affiliations, the next analysis focused on mapping the terms most frequently used by researchers, as shown in Figure 4.

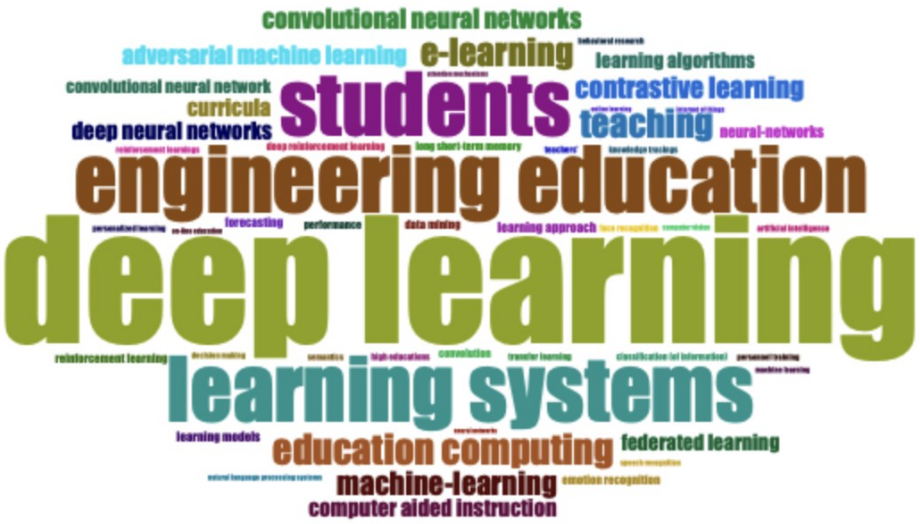

Figure 4. WordCloud

Term frequency analysis shows that "deep learning" dominates with 851 occurrences, confirming its position as a primary research focus in the field of education. Other frequently used terms include "engineering education" (448), "learning systems" (437), and "students" (427), illustrating the close relationship between technological development and its application in learning systems and the central role of learners. Furthermore, terms such as "educational computing" (206), "teaching" (193), and "e-learning" (189) emphasize the integration of computing and digital technology into educational practice. Meanwhile, a number of technical terms related to artificial intelligence, such as "machine learning" (158), "contrastive learning" (145), "convolutional neural networks" (135), "adversarial machine learning" (124), and "deep neural networks" (119), demonstrate the strong influence of computer science in supporting the development of learning methodologies. In terms of thematic focus, the dominance of terms such as deep learning, engineering education, learning systems, and students confirms that much research is directed at developing technology-based learning systems, particularly to support engineering and computing education. However, recent trends highlighting contrastive learning, adaptive learning, and short-term memory indicate a shift toward a more personalized approach oriented toward students' cognitive processes. This development opens up new opportunities to utilize deep learning not only as a technical tool but also as a pedagogical approach that supports meaningful, joyful learning, and strengthens HOTS at various levels of education. Thus, this keyword pattern indicates both the significant potential and the gap that still needs to be bridged between technological innovation and its application in everyday educational practice. To understand the conceptual link between these terms, the analysis continues with the Co-occurrence Network visualization in Figure 5.

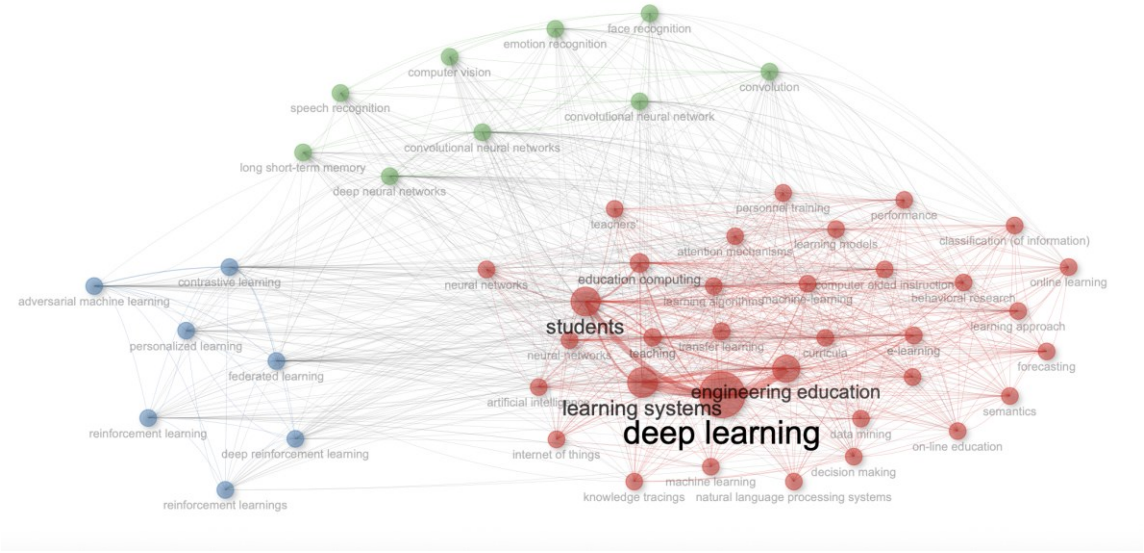

Figure 5. Co-occurrence Network

The results of the Co-occurrence Network analysis show a strong connection between dominant keywords such as "deep learning," "learning systems," "engineering education," and "students," which form the core of the research network. The red cluster indicates a primary focus on the integration of deep learning-based technology with learning systems and engineering education, as well as its relationship to pedagogical concepts such as online learning, teaching, curricula, and data mining. Meanwhile, the blue cluster indicates a more specific research theme on the development of artificial intelligence methods, such as reinforcement learning, federated learning, contrastive learning, and adversarial machine learning, which emphasizes the diversification of computational approaches in education. On the other hand, the green cluster emphasizes the application of deep learning in the field of pattern recognition, including computer vision, speech recognition, emotion recognition, and convolutional neural networks. This pattern indicates that research on the topic of deep learning in education is not only focused on the technical aspects of algorithm development, but also on expanding its applications in digital learning, personalized learning, and human-machine interaction. Thus, the Co-occurrence Network provides a clear visual depiction of the evolving conceptual research ecosystem, while also emphasizing the close

relationship between innovation in computing technology and the transformation of modern education. To strengthen our understanding of the direction of development of these research issues, further analysis is presented in Figure 6. Trend Topics, which displays the dynamics of research topics over time.

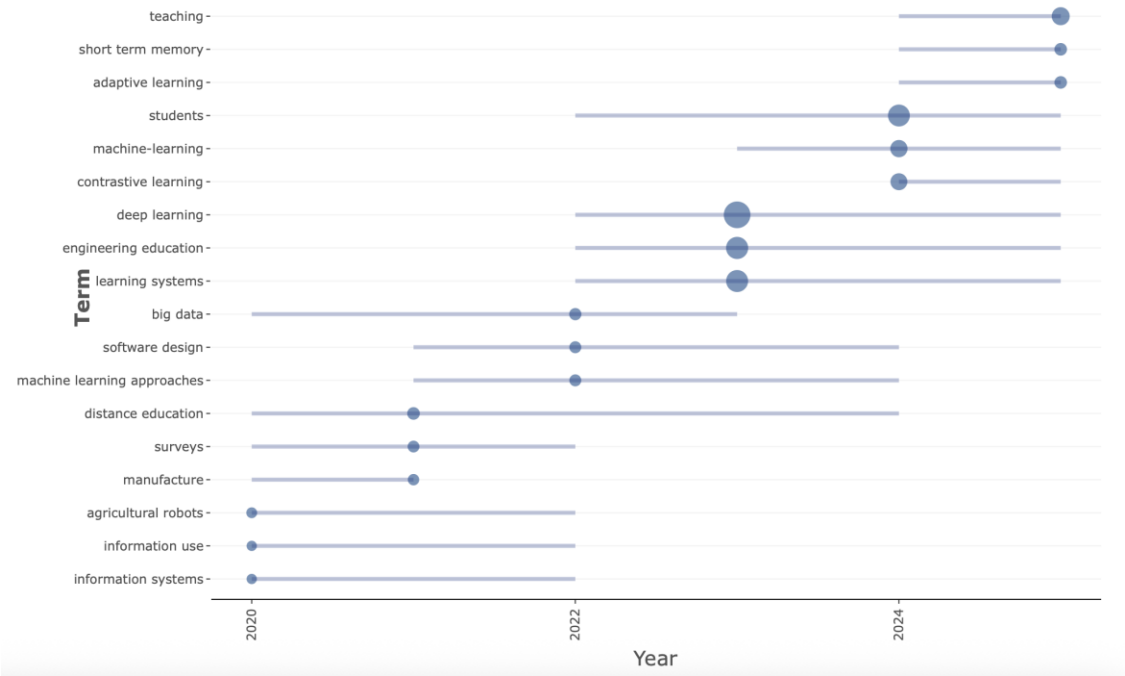

Figure 7. Trend Topics

Trend Topics data shows the dynamic evolution of research focus on deep learning approaches in education from 2020 to 2025. At the beginning of the period, emerging topics were still oriented towards general applications and supporting technologies, such as agricultural robots, information systems, information use, and distance education, which are highly relevant to the needs of online learning due to the COVID-19 pandemic (Hashem et al., 2021). Entering 2021–2022, the research focus began to shift to more complex computing issues, such as big data, machine learning approaches, and software design, which serve as essential foundations for integrating deep learning into education. Since 2022, there has been a significant surge in key terms such as deep learning, engineering education, learning systems, and students, which will dominate until 2025. This shift indicates that research is no longer solely focused on supporting technologies but is moving towards the concrete application of deep learning in educational practice to improve the quality of learning (Gao, 2025).

Recent trends in 2024–2025 highlight more specific and applicable topics, such as contrastive learning, teaching, adaptive learning, and short-term memory. The emergence of these terms reflects innovative explorations into personalized learning, memory strengthening, and more learner-oriented AI-based teaching strategies. This analysis shows that while dominant topics such as deep learning, engineering education, and learning systems remain the focus, research is shifting toward integrating cognitive approaches and personalized learning, which are relevant to the demands of 21st-century education (Nuraini & Shahbodin, 2015). Potential future research could be directed at exploring how deep learning-based adaptive learning approaches can increase student engagement, strengthen HOTS, and support the implementation of the Merdeka Belajar policy in Indonesia. Furthermore, the integration of contrastive learning with a cross-disciplinary collaborative learning context opens up strategic opportunities to create more innovative, inclusive, and sustainable educational models in the digital era.

CONCLUSION

This bibliometric analysis confirms that deep learning approaches in education have transformed from a mere technological trend into a strategic research domain, with a growing focus on pedagogical innovation and personalized learning. The surge in publications, the diversity of sources, and the

emergence of new keywords indicates that the field is entering a phase of scientific consolidation, where conceptual debates and experiments are developing toward more mature applications. Another important finding is the regional dominance of research contributions, opening up opportunities for broader international collaboration to enrich global perspectives. Furthermore, the shifting trend toward adaptive learning, contrastive learning, and the integration of cognitive aspects indicates that future research will focus not only on technological development but also on how this technology can shape learning experiences that are more humanistic, inclusive, and relevant to the needs of the 21st century.

REFERENCES

Akmal, A. N., Maelasari, N., & Lusiana, L. (2025). Pemahaman Deep Learning dalam Pendidikan: Analisis Literatur melalui Metode Systematic Literature Review (SLR). *JIIP-Jurnal Ilmiah Ilmu Pendidikan*, *8*(3), 3229-3236.

Andayanie, L. M., Adhantoro, M. S., Purnomo, E., & Kurniaji, G. T. (2025). Implementation of Deep Learning in Education: Towards Mindful, Meaningful, and Joyful Learning Experiences. *Journal of Deep Learning*, 47-56.

Apino, E., & Retnawati, H. (2018). Creative problem solving for improving students' higher order thinking skills (HOTS) and characters. In *Character Education for 21st Century Global Citizens* (pp. 249-256). Routledge.

Chang, C. C., Hwang, G. J., & Tu, Y. F. (2023). Roles, applications, and trends of concept map-supported learning: A systematic review and bibliometric analysis of publications from 1992 to 2020 in selected educational technology journals. *Interactive Learning Environments*, *31*(9), 5995-6016.

Chen, X., Zou, D., Xie, H., & Wang, F. L. (2021). Past, present, and future of smart learning: a topic-based bibliometric analysis. *International Journal of Educational Technology in Higher Education*, *18*(1), 2.

Chosya, J. A., & Takiddin, T. (2025). Developing Deep Learning-Based Worksheets to Improve Higher-Order Thinking Skills in Elementary Social Studies. *Journal of Deep Learning*, 37-46.

Feriyanto, F., & Anjariyah, D. (2024). Deep learning approach through meaningful, mindful, and joyful learning: A library research. *Electronic Journal of Education, Social Economics and Technology*, *5*(2), 208-212.

Gao, J., Huang, X., & Zhang, L. (2019). Comparative analysis between international research hotspots and national-level policy keywords on artificial intelligence in China from 2009 to 2018. *Sustainability*, *11*(23), 6574.

Gao, Y. (2025). Deep learning-based strategies for evaluating and enhancing university teaching quality. *Computers and Education: Artificial Intelligence*, *8*, 100362.

Guan, C., Mou, J., & Jiang, Z. (2020). Artificial intelligence innovation in education: A twenty-year data-driven historical analysis. *International Journal of Innovation Studies*, *4*(4), 134-147.

Hashem, N. M., Hassanein, E. M., Hocquette, J. F., Gonzalez-Bulnes, A., Ahmed, F. A., Attia, Y. A., & Asiry, K. A. (2021). Agro-livestock farming system sustainability during the COVID-19 era: A cross-sectional study on the role of information and communication technologies. *Sustainability*, *13*(12), 6521.

Huang, C., Yang, C., Wang, S., Wu, W., Su, J., & Liang, C. (2020). Evolution of topics in education research: A systematic review using bibliometric analysis. *Educational Review*, *72*(3), 281-297.

Ilgun Dibek, M., Sahin Kursad, M., & Erdogan, T. (2025). Influence of artificial intelligence tools on higher order thinking skills: a meta-analysis. *Interactive Learning Environments*, *33*(3), 2216-2238.

Kamaruldzaman, M. L. H., Osman, K., & Diyana Mahmud, S. N. (2025). Cultivating Green Minds: A Systematic Review of Teaching Strategies, Outcome and Challenges in Education for Sustainable Development (ESD) for Secondary Schools. *e-BANGI Journal*, *22*(2).

Nuraini, C. K., & Shahbodin, F. (2015). Personalized learning environment (PLE) integration in the 21st century classroom. *International Journal of Computer Information Systems and Industrial Management Applications*, *7*, 8-8.

Perrotta, C., & Selwyn, N. (2020). Deep learning goes to school: Toward a relational understanding of AI in education. *Learning, media and technology*, *45*(3), 251-269.

Pranckutė, R. (2021). Web of Science (WoS) and Scopus: The titans of bibliographic information in today's academic world. *Publications*, *9*(1), 12.

Prihantoro, P., Prayitno, H. J., Indri, I., & Kusumaningtyas, D. A. (2025). Deep Learning: Policies, Concepts, and Implementation in Senior High Schools in Indonesia. *Journal of Deep Learning*, 11-24.

Ratnawati, R. E., Christiani, Y. H., & Karim, A. (2024). Optimization of character education in the independent curriculum through the Pancasila student profile strengthening project approach. *IJESS International Journal of Education and Social Science*, *5*(1), 16-30.

Rissi, A. R. Y., & Sinaga, D. (2025). AI Dan Pembelajaran Mendalam (Deep Learning): Meningkatkan Kualitas Pendidikan Di Era Digital. *Cetta: Jurnal Ilmu Pendidikan*, *8*(4), 10-23.

Su, M., Peng, H., & Li, S. (2021). A visualized bibliometric analysis of mapping research trends of machine learning in engineering (MLE). *Expert Systems with Applications*, *186*, 115728.

Taqiyya, W., Utami, R. D., Samsuri, M., & Siswanto, H. (2025). Strategies of Deep Learning to Foster Meaningful and Sustainable Education in the 21st Century. *Journal of Deep Learning*, 127-138.

Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., ... & Lubart, T. (2023). Creativity, critical thinking, communication, and collaboration: Assessment, certification, and promotion of 21st century skills for the future of work and education. *Journal of Intelligence*, *11*(3), 54.

Weng, C., Chen, C., & Ai, X. (2023). A pedagogical study on promoting students' deep learning through design-based learning. *International journal of technology and design education*, *33*(4), 1653-1674.

Wibawa, I. M. C. (2023). Improving Student Science Learning Outcomes Through Cooperative Learning: Early Childhood Students Through Small Groups. *Indonesian Journal of Educational Development (IJED)*, *4*(1), 118-125.

Zebua, N. (2025). Education Transformation: Implementation of Deep Learning in 21st-Century Learning. *Harmoni Pendidikan: Jurnal Ilmu Pendidikan*, *2*(2), 146-152.

Zebua, N. (2025). Education Transformation: Implementation of Deep Learning in 21st-Century Learning. *Harmoni Pendidikan: Jurnal Ilmu Pendidikan*, *2*(2), 146-152.