***Science Education and Application Journal (SEAJ)***
***Program Studi Pendidikan IPA***
***Universitas Islam Lamongan***
*http://jurnalpendidikan.unisla.ac.id/index.php/SEAJ*

*March, 2025. Vol. 7, No. 1,*
*p-ISSN: 2656-6672*
*e-ISSN: 2656-8365*
*pp. 22-30*

# Deep Learning Model in Science Learning: Bibliometric Analysis

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***Article Info***

***Article History***
*Received: Jan, 18th, 2025*
*Revised: Jan, 27th, 2025*
*Published: Jan, 31st, 2025*

***Keywords***
*Deep Learning; Science Learning; Bibliometrics; Education*

***Abstract***

*The deep learning model is one of the learning models that can be applied in science learning. Research related to deep learning has grown very rapidly in recent years. Research on deep learning models has produced many theoretical and empirical findings. Many trends have emerged to highlight the complexity and dynamics of deep learning models in science learning. This study aims to discover the latest trends in deep learning model research in science learning. This study uses a bibliometric approach of analysis based on the Google Scholar database. Based on this study's title, abstract, and keywords, it produced 872 studies from 2015-2024. The results of this study show that the deep learning model in this learning has increased significantly in 2022. The increase in research on deep learning models shows the importance of applying deep learning models in learning.*



***Citations:*** Happy, N., Santosa, T. A., Hiola, S. F., Safira, I., Latifah, N., Dewanto, Muh. S., & Nugraha, A. R. (2025). Deep Learning Model in Science Learning: Bibliometric Analysis. Science Education and Application Journal (SEAJ), 7(1), 22-30.

## INTRODUCTION

Science education has a strategic role in preparing students to face increasingly complex global challenges in the era of the Industrial Revolution 5.0(Asnur et al., 2024; Zulyusri et al., 2023; Saputra et al., 2023; Zulkifli et al., 2022). Challenges such as climate change, advanced technological developments, food security, and global health demand critical thinking, problem-solving, and science-based innovation. Through science education, students not only understand scientific concepts in depth but are also trained to apply this knowledge in real contexts. (Ajibade et al., 2023; Bidwe et al., 2022). This approach is important to produce a generation that can provide science-based solutions to world problems, both at the local and global levels.(Ali et al., 2022; Ichsan et al., 2023). In addition, science education also encourages the mastery of 21st-century skills, such as digital literacy, collaboration, and effective communication skills, all of which are necessary to face an increasingly dynamic and technology-based world of work. (Miraftabzadeh et al., 2024).

Furthermore, amid increasingly integrated globalization, science education also catalyzes to building of students' global competencies, such as cross-cultural understanding, scientific ethics, and awareness of global issues (Y. Li & Zhong, 2024). Through project-based learning and research, students are trained to collaborate in multidisciplinary teams, integrate advanced technology, and analyze complex data to make informed decisions(Khairi et al., 2022; Sobral, 2021). This allows them to contribute significantly to addressing global challenges, such as sustainable management of natural resources and the development of environmentally friendly technologies (Ivanova et al., 2024; Dewanto et al., 2023). Thus, science education is not only about knowledge transfer, but also about forming a scientific mindset that is solution-oriented, sustainable, and globally relevant (Valencia-Arias et al., 2024).

Science education cannot be separated from the evolution of learning models that continue to evolve along with technological advances. In the face of global challenges, the integration of technology in science education is an important solution to ensure that students can understand scientific concepts in-depth and relevant to the needs of the times. (Bhattacharya, 2019). Technological developments such as artificial intelligence, virtual reality, and data-driven learning have changed the way students learn, from a passive, conventional approach to an interactive, collaborative, and experience-based learning model. (Ajibade , et al., 2023). This technology allows students to explore complex scientific phenomena through simulations, virtual experiments, and data analysis in real time so that they can develop the critical and innovative thinking skills necessary to solve global problems. (Chen et al., 2024; Agbo et al., 2021; Nurtamam et al., 2023; Luciana et al., 2024).

In addition, a learning model that integrates technology is Deep Learning. Deep learning models have opened up new opportunities in science education. (Miraftabzadeh et al., 2024;Li & Zhong, 2024; Khairi et al., 2022). This technology not only helps students understand abstract concepts but also allows them to personalize learning according to their individual needs and interests. (Ali et al., 2022). The use of Deep Learning algorithms can analyze students' learning patterns and provide adaptive feedback to improve their understanding. Thus, the evolution of technology-based learning models not only supports the goals of science education but also strengthens students' ability to face global challenges more effectively and innovatively. (Bidwe et al., 2022; Wantu et al., 2024).

Deep Learning (DL) is a branch of artificial intelligence (AI) that focuses on processing complex data through artificial neural networks that have many layers. (Ovcharenko et al., 2024; Saputra et al., 2023). This technology is designed to mimic the way the human brain works in analyzing and processing information, so it can recognize patterns, predict, and make decisions automatically based on large and complex data. In the context of education (Agbo et al., 2021), Deep Learning has great potential to increase the effectiveness of learning, including in the field of science learning (Chen et al., 2024; Djeki et al., 2022; Oktarina et al., 2021; Santosa & Aprilisia, 2022). With the ability to personalize learning, DL can analyze students' needs and preferences individually, provide adaptive feedback, and present relevant and interactive learning content. In addition, DL also allows the development of technology-based learning platforms, such as virtual tutors, content recommendation systems, and real-time analysis of student performance. (Chen et al., 2021).

Although the application of deep learning in science education has shown significant potential, the research available today still points to several gaps that need to be filled. Most studies focus on DL applications for the development of AI-based learning technologies, such as virtual tutors and interactive simulations, but pay less attention to comprehensive mapping of global trends in the application of DL in science learning (Sobral, 2021). In addition, previous research has tended to address specific cases at a particular level of implementation, such as in physics or biology subjects (Ali et al., 2022), without explaining cross-disciplinary relationships in science education as a whole(Wang et al., 2024; Chen et al., 2021). This creates the need for a broader study, which not only discusses the results of DL implementation but also analyzes publication patterns, researcher collaboration, and temporal developments in the related scientific literature.

Furthermore, the limited bibliometric analysis related to DL in science learning poses challenges in understanding the geographical distribution of research, collaboration networks between researchers, and trending topics. Bibliometric analysis is important to provide a comprehensive picture of how DL has been used in science learning, including the identification of unfilled research gaps. On the other hand, most studies have also not explicitly evaluated the impact of DL on science learning from the perspective of student learning outcomes, teaching effectiveness, and efficiency of technology implementation. Therefore, this study aims to fill the gap through a comprehensive bibliometric approach, so that it can provide strategic guidance for researchers and educators to optimize the application of Deep Learning in science learning. This study aims to analyze a comprehensive research that focuses on bibliometric analysis of deep learning models in science learning with the help of Scopus and VOSviewer databases.

## METHODS

This research is a quantitative research with a bibliometric approach, analysis is carried out with literature sourced from the Scopus and Vosviewer databases which function to determine the distribution and contribution of articles. Bibliometrics serves to find out comprehensively the research to be researched. The sources of this study are sourced from Scopus, Google Scholar, ERIC, and Wiley. The data obtained from the database are 872 studies published in 2015-2024. According to Dawana et al., (2022) The bibliometric research procedure can be seen in Figure 1.

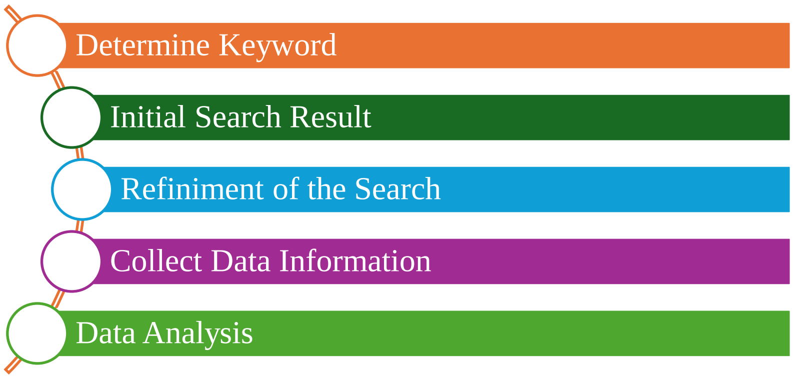


**Figure 1.** Bibliometric Research Procedure

Data analysis in the study was carried out by mapping research trends using Microsoft Excel and VOSviewer applications by describing Co-occurrence and collaboration between authors, relationships between studies, author keywords, and research publications on the researched research.

## RESULTS AND DISCUSSION

Based on the results of data search through the Scopus database, 134 studies were obtained, Google Scholar 345 researches, ERIC 67 researches, and Wiley 326 studies with the search keyword "Deep Learning in Science Learning" published in 2015-2024. Furthermore, 150 studies are using the ScienceDirect database with the keywords "deep learning" and "science (Physics, Biology, and Chemistry)" learning stored in RIS format. The research data that has been obtained is visualized using the VOSviewer application. Detailed document types can be seen in Table 1.

Table 1. Number of Documents of Types

| Document | Number of Documents (%) |
|---|---|
| Conference Paper | 6 ( 18.75) |
| Journal | 18 (56.25) |
| Book Chapter | 3 (9.38) |
| Review | 5 ( 15.62) |

Based on Table 1, the most commonly found types of documents are journals with the topics "Deep learning", and "Science Learning". So far there have been no publications of books related to this topic. Furthermore, the popularity of publications can be seen from the number of citations. The 7 articles with the highest number of citations can be seen in Table 2.

Table 2. 7 Most Relevant Studies from Databases

| Author | Publisher | Cited |
|---|---|---|
| Wang et al., (2020) | Springer | 295 |
| Han et al., (2019) | IEEE | 190 |
| Li et al.l (2022) | Wiley | 6 |
| Edosa ( 2023) | IEEE | 3 |
| Harbi ( 2022) | Springer | 2 |
| Al-Maghrabi (2019) | IEEE | 2 |
| Loey (2020) | IEEE | 2 |

Table 2, shows that the systematic review has collected the highest number of citations. In addition, the quote relates to the contributions of the countries affiliated with the article. Lima negara dengan afiliasi tertinggi dalam penelitian yang dapat dilihat pada Tabel 3.

Table 3. Top-5 Country Affiliations in Scopus

| Rank | Country | Number of Document |
|---|---|---|
| 1 | China | 6 |
| 2 | Inggris | 5 |
| 3 | Malaysia | 5 |
| 4 | Argentina | 3 |
| 5 | Turki | 2 |

Based on Table 3. China dominated the most affiliated authors related to this study. In the study, there was no dominance by one country in this study. Furthermore, visualize the data in the research with the VOSviewer application by analyzing the title, keywords, and abstracts to find a deep understanding of this topic. In this study, 875 studies were imported into the VOSviewer application. The visualization results can be seen in Figure 2.

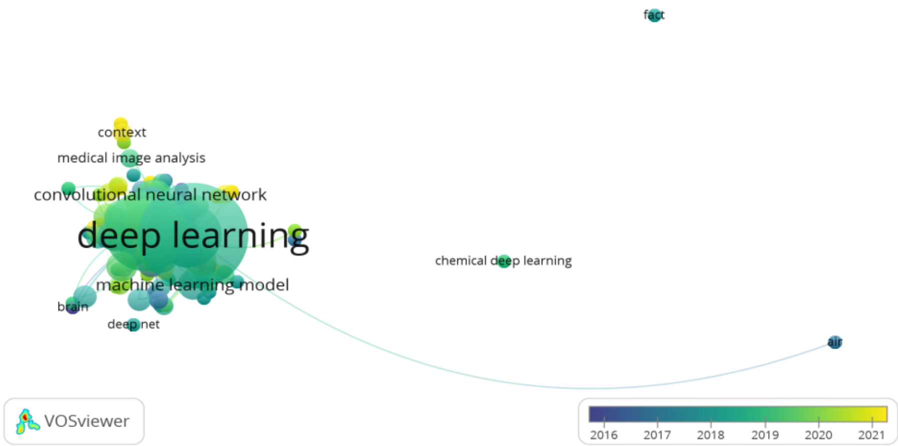


**Figure 2.** Deep Learning Visualization In Science Learning

Based on Figure 2, it shows that there is a relationship between one research and another. Finding the number and size of the cluster requires advanced parameters. Furthermore, the visualization of deep learning in science learning has a research relationship that can be seen in Figure 3.

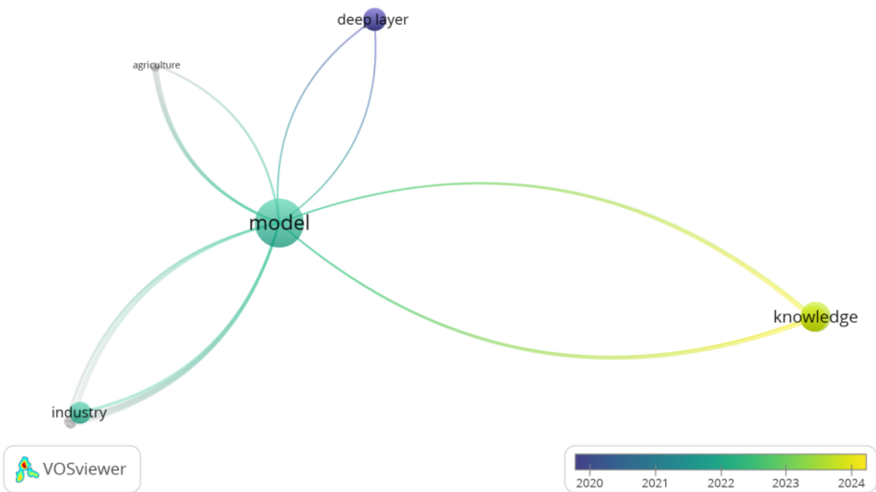


**Figure 3.** Network Mapp Deep Learning in Science Learning

Gambar 3, menjelaskan mode deep elarning dalam pembelajaran IPA banyak diteliti terkait dengan ”knowledge”, ” deep learning”, ” agriculture” dan ” industry”. Deep learning has emerged as a revolutionary method in various fields, including education, where its applications are increasingly explored in science learning. Bibliometric analysis provides a systematic approach to evaluate trends, influential works, and key themes in this domain. Deep learning models, particularly those based on artificial neural networks(Chandra et al., 2023; Mu et al., 2023;  Li et al., 2022), offer opportunities to enhance personalized learning, automate assessment, and improve students' conceptual understanding (Zhong et al., 2021; Shoaib et al., 2023; Khashman et al., 2020). In science learning, these models can analyze complex data patterns and provide feedback tailored to individual students' learning needs, fostering better engagement and outcomes.

The bibliometric analysis of studies on deep learning in science education highlights the growth of scholarly interest and collaboration among researchers across the globe. A review of publication databases such as Scopus or Web of Science reveals that countries like the United States, China, and

European nations dominate in contributions to this field. The analysis also shows that journals focusing on educational technology and interdisciplinary research frequently publish studies related to this topic (Yuan et al., 2017). Key authors and institutions have played pivotal roles in advancing theoretical frameworks and practical implementations of deep learning in science education (Choudhary et al., 2022; Yang et al., 2021).

The use of deep learning models in science education addresses several challenges faced by educators. For instance, traditional teaching methods often struggle to cater to diverse learning styles and paces. (Amini et al., 2023). Deep learning algorithms, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), enable adaptive learning environments by analyzing large volumes of student interaction data. These models can predict learning difficulties, recommend suitable instructional strategies, and foster collaborative learning through intelligent virtual environments. Consequently, they bridge the gap between theoretical science content and practical understanding, essential for 21st-century learners. (Jescovitch et al., 2021; Rustam et al., 2021).

Bibliometric findings indicate an increasing emphasis on specific applications, such as the integration of deep learning in experimental simulations, data visualization, and natural language processing in science curricula. However, challenges remain, including data privacy concerns, the need for substantial computational resources, and a lack of teacher training to effectively implement these technologies. (Wissler et al., 2005). Future research should address these gaps by exploring more accessible and ethical frameworks for applying deep learning in diverse educational settings. Furthermore, interdisciplinary collaboration between educators, data scientists, and policymakers is crucial to maximize the impact of these innovations. (Wibawa et al., 2024).

In conclusion, deep learning holds immense potential to transform science education by making learning more personalized, engaging, and effective. Bibliometric analysis underscores the growing research attention in this area while also revealing opportunities for further exploration.(Wibawa et al., 2022; Chandra et al., 2023). To fully harness the benefits of deep learning, stakeholders must address current challenges and promote equitable access to technology-driven solutions. With sustained effort and innovation, deep learning models can redefine the future of science learning, equipping students with the skills needed for complex problem-solving and critical thinking in a rapidly evolving world.

## CONCLUSION

From this study, it can be concluded that the deep learning model in this learning has experienced a significant increase in 2022. The increase in research on deep learning models shows the importance of applying deep learning models in learning. These findings show that deep learning technology not only improves student learning outcomes but also helps educators overcome challenges in meeting the individual needs of students in the era of technology-based education. This has implications for educators to start integrating Deep Learning-based technologies as part of the science curriculum. The development of artificial intelligence-based learning content can not only help students understand the material in depth but also encourage critical and creative thinking skills, which are the main need in the era of the Industrial Revolution 5.0.

In addition, the implications of this research can also be felt in the development of educational policies that support the use of AI-based technology in the school environment. Educational institutions need to increase the capacity of digital infrastructure and train teachers to be able to use Deep Learning effectively in the learning process. The results of this bibliometric show that research in this field continues to grow rapidly, so policymakers need to provide a space for collaboration between academics, technology developers, and education practitioners. This step is expected to create an innovative and relevant learning ecosystem for the times so that it can produce human resources who are ready to compete globally.

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