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Scientometric Analysis: Trends in Deep Learning Research in the Context of Higher Education

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Abstract
This study aims to map research trends regarding the application of deep learning in the context of higher education through a bibliometric approach based on Scopus data for the period 2015–2025. The analysis was conducted using the Bibliometrix package with the Biblioshiny interface in RStudio to explore various indicators, such as annual publication trends, citation distribution, contributions by country and institution, and collaboration patterns among authors. Additionally, this study utilizes visualizations such as three-field plots (Sankey diagrams), network analysis, word clouds, and tree maps to identify relationships between elements and thematic clusters in the literature. The results indicate a significant increase in the number of publications, with contributions predominantly coming from countries such as China and the United States. Citation analysis indicates an uneven distribution of scientific impact, where some articles have a more dominant influence than others. Thematically, research is developing along two main trends: a technical approach focused on the development of artificial intelligence systems and a pedagogical approach highlighting its impact on the learning process. These findings indicate that deep learning is not only positioned as a technological innovation but also as a strategy for building adaptive, personalized, and data-driven learning systems. Overall, this study provides a comprehensive overview of the direction and dynamics of global research, while also opening up opportunities for future collaboration and the advancement of research in this field.

Keywords: *artificial intelligence, bibliometric, biblioshiny, deep learning, deep learning, higher education*

Abstrak
Penelitian ini bertujuan untuk memetakan tren riset mengenai penerapan deep learning dalam konteks pendidikan tinggi melalui pendekatan bibliometrik berbasis data Scopus selama periode 2015–2025. Analisis dilakukan menggunakan paket Bibliometrix dengan antarmuka Biblioshiny pada RStudio untuk mengeksplorasi berbagai indikator, seperti tren publikasi tahunan, distribusi sitasi, kontribusi negara dan institusi, serta pola kolaborasi antar penulis. Selain itu, penelitian ini juga memanfaatkan visualisasi seperti three-field plot (Sankey diagram), network analysis, word cloud, dan tree map untuk mengidentifikasi keterkaitan antar elemen serta klaster tematik dalam literatur. Hasil penelitian menunjukkan bahwa jumlah publikasi mengalami peningkatan yang signifikan dengan dominasi kontribusi dari negara-negara seperti Tiongkok dan Amerika Serikat. Analisis sitasi mengindikasikan adanya distribusi dampak ilmiah yang tidak merata, di mana sebagian artikel memiliki pengaruh yang lebih dominan dibandingkan yang lain. Dari sisi tematik, riset berkembang dalam dua kecenderungan utama, yaitu pendekatan teknis yang berfokus pada pengembangan sistem kecerdasan buatan dan pendekatan pedagogis yang menyoroti dampaknya terhadap proses pembelajaran. Temuan ini menunjukkan bahwa deep learning tidak hanya diposisikan sebagai inovasi teknologi, tetapi juga sebagai strategi dalam membangun sistem pembelajaran yang adaptif, personal, dan berbasis data. Secara keseluruhan, penelitian ini memberikan gambaran komprehensif mengenai arah dan dinamika riset global, sekaligus membuka peluang pengembangan kolaborasi dan penguatan kajian di masa mendatang.

Kata kunci: *kecerdasan buatan, bibliometrik, biblioshiny, pembelajaran mendalam, transformasi digital, pendidikan tinggi.*

INTRODUCTION

The development of artificial intelligence technology in recent years has shown an increasingly rapid pace, particularly in the field of deep learning, which is now widely utilized across various sectors, including higher education. From a more technical perspective, deep learning as a subset of machine learning possesses the capability to process large-scale data in a more complex manner, thereby enabling the emergence of systems that are not only automated but also capable of making predictions and

adapting to user needs (Chen, Chen, & Lin, 2020; Ouyang & Jiao, 2021). Amid the wave of digital transformation, the application of this technology is becoming evident across various aspects of higher education, ranging from online learning systems, curriculum development, to the evaluation of students' academic achievements.

Upon closer examination, the integration of deep learning extends beyond the technological aspect alone (Zhao, 2023). There is a shift in the approach to learning design, becoming more adaptive and data-driven. For instance, the emergence of intelligent e-learning systems capable of recommending materials, mapping learning progress, and even identifying individual student needs with greater specificity (Zhang, 2023). A number of studies have also shown that the use of artificial intelligence in education can enhance the effectiveness of learning while providing a more personalized and responsive learning experience (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

However, despite the growing attention to this topic, one significant issue remains: there are still few systematic studies that map the development of deep learning research within the context of higher education. While information regarding publication trends, author and institutional contributions, and major research themes is already quite extensive, it remains scattered and has not yet been comprehensively organized. In fact, such mapping is crucial, not only to assess the extent of this field's development but also to identify opportunities for collaboration and future research directions (Saputra, Bin Suparti, & Hamizah Binti Mohamad Latip, 2025).

Given these circumstances, this study aims to conduct a scientometric analysis of deep learning research trends in higher education using a bibliometric approach. Data were obtained from the Scopus database and analyzed using Biblioshiny within the Bibliometrix package on the RStudio platform (Puspitasari, Istanto, Apriantoro, & El Ashfahany, 2023). Through this approach, the study not only examines the number of publications but also seeks to understand patterns of research development through various indicators such as annual trends, citations, contributions by country and institution, keyword distribution, and collaboration patterns among authors. Thus, it is hoped that a more comprehensive picture of the dynamics and direction of deep learning research in higher education during the 2015–2025 period will be obtained.

The analysis in this study does not focus solely on quantitative data but also seeks to uncover the interconnections among elements in scientific publications by mapping relationships between authors, journals, and keywords using a three-field plot or Sankey diagram. Additionally, keyword co-occurrence visualizations based on network analysis are employed to identify emerging thematic clusters within the literature. Such visual approaches are crucial as they help elucidate patterns that may not be immediately apparent from statistical figures, thereby making data interpretation more contextual and comprehensive (Aria & Cuccurullo, 2017; Donthu, Kumar, Mukherjee, Pandey, & Lim, 2021). In this way, the research does not merely stop at mapping global publication trends related to deep learning in higher education but also seeks to capture the dynamics of scholarly relationships and open up possibilities for more strategic directions of collaboration and research development in the future.

METHOD

This study employs a scientometric-based bibliometric approach to examine trends, themes, and collaboration patterns in deep learning research within the context of higher education during the 2015–2025 period. This approach was chosen because it provides not only quantitative but also visual insights into the structure and dynamics of a scientific field's development through the analysis of scientific publication metadata (Donthu et al., 2021). The primary data source for this study comes from the Scopus database, which was selected for its broad coverage and recognized indexing quality in international scientific publications (Mongeon & Paul-Hus, 2016). Data collection was conducted by searching for articles using a combination of keywords such as "deep learning," "higher education," "university," and "college," focusing on the title, abstract, and keywords. The publication timeframe was limited to the years 2015 through 2025 to capture research developments over the past decade.

To ensure data relevance and quality, only English-language journal articles with complete metadata were included in the analysis, while documents such as editorials, reviews, conference proceedings, and publications lacking adequate bibliographic information were excluded from the dataset (Saputra, 2025). The bibliographic data obtained was then exported in BibTeX format and underwent a cleaning process, including the removal of duplicates and the correction of data inconsistencies using Microsoft Excel. The next stage involved data analysis using RStudio software via the Bibliometrix package and the Biblioshiny interface, which enabled the exploration of various indicators such as publication trends, citation patterns, keyword distribution, and collaboration networks among authors and institutions. Through this process, the study aims to provide a more systematic and comprehensive overview of the development of deep learning research in higher education.
The inclusion criteria applied include:

Table 1. Inclusion and Exclusion Criteria

Inclusion	Exclusion
Articles published between 2015 and 2025.	Articles published before 2015.
The study focuses on interactive learning at the university level.	Research conducted at the elementary, middle, or high school level.
The study was conducted nationwide.	Research conducted in a single country with local contextual relevance.
The articles are available in English and have complete metadata for analysis.	Articles without full access (abstracts only)
The publications are scientific journals.	Reviews, editorials, and non-empirical research are distinct types of writing in the context of research and critical thinking.

Data analysis in this study was conducted using RStudio software via the Bibliometrix package and the Biblioshiny visual interface, which are widely used in bibliometric studies to explore the structure and dynamics of scientific publications (Aria & Cuccurullo, 2017). Key indicators analyzed include the number of publications per year, contribution trends by country, average annual citations, and the frequency and co-occurrence of keywords. Additionally, this study examines collaboration patterns among authors and institutions, while identifying the most productive authors and journals in this field (Saputra & Bin Suparti, 2025). To enhance understanding of the relationships among these elements, visual mapping tools such as Sankey diagrams were used to connect authors, journals, and dominant keywords (Saputra, Sumarni, Balkis, Solikhin, & Faqih, 2025). Further visualization is conducted through network analysis, tree maps, and word clouds to uncover thematic clusters emerging in the literature (Yokhebed, Sutarno, Masykuri, & Prayitno, 2023). Through this combination of quantitative analysis and visual approaches, the study aims to provide a more comprehensive overview of the direction of development, scientific dynamics, and potential for collaboration in deep learning research within the context of global higher education.

RESULTS AND DISCUSSION

Analysis of the Average Number of Citations per Year for Articles on Deep Learning in the Context of Higher Education from 2015 to 2025. Citation rates are often used as an indicator of the extent to which a study has an impact and makes a contribution to the scientific community (Ellegaard & Wallin, 2015). In this context, analyzing the average number of citations per year is important because it provides insight into the dynamics of academic interest in the topic of deep learning in higher

education over time. A higher citation rate typically indicates that a study has strong relevance and is frequently cited by other studies (Bornmann & Mutz, 2015; Donthu et al., 2021). Therefore, through this analysis, it is possible to trace the development of interest and the intensity of research on this topic over a specific time period. The graph presented below illustrates the trend in the average number of citations per article during the period from 2015 to 2025, which simultaneously reflects the patterns of growth and distribution of scientific impact in this field.

The average trend in the number of citations per article each year for publications related to deep learning in the context of higher education during the 2015–2025 period.

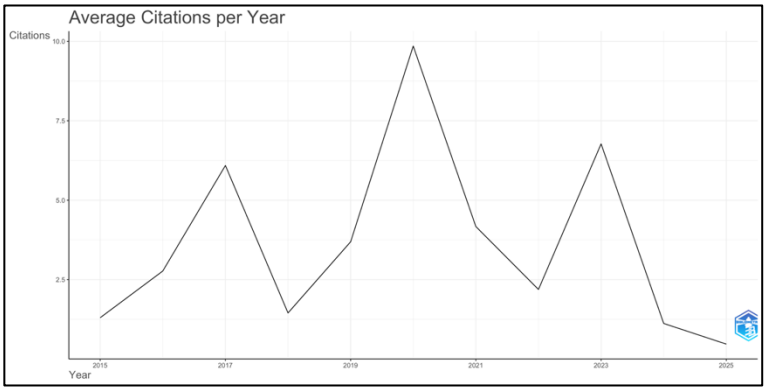

Figure 1. Annual trend in the average number of citations per article

Figure 1 shows the annual trend in the average number of citations per article for publications related to deep learning in the context of higher education during the 2015–2025 period. In general, it is evident that the citation pattern exhibits fairly dynamic fluctuations. In the initial phase, from around 2015 to 2017, there was a significant increase reaching an initial peak, indicating that publications during that period began to gain attention and were cited as references in subsequent research. However, a decline was observed in 2018, which may indicate a shift in focus or the instability of research development during that phase.

Interestingly, a resurgence occurred around 2020 with a higher average citation rate compared to the previous period. This is likely related to the growing global interest in artificial intelligence-based technologies, particularly amid the acceleration of digital transformation across various sectors, including education. After reaching that point, the citation trend again showed a gradual decline in subsequent years, although it experienced a slight increase during certain periods. This pattern shows that the distribution of citations tends to be uneven and is more concentrated in certain publications that have a significant influence. Overall, this trend indicates that although the number of research studies continues to grow, not all publications receive the same level of attention; thus, quality, topic relevance, and publication timing are key factors in determining an article's scientific impact.

Word Cloud Analysis of Articles on Deep Learning in the Context of Higher Education from 2015 to 2025

Figure 2. Word Cloud

Figure 2 displays a word cloud visualization illustrating the frequency of keyword occurrences in publications related to deep learning in the context of higher education during the 2015–2025 period. From this visualization, it is evident that the term "deep learning" is the most dominant keyword, indirectly affirming its position as the primary focus of this study. However, what is interesting is not only the dominance of this term but also the emergence of other words such as "students," "learning systems," and "education computing," which indicate that the research focus is not solely on technical aspects but is also beginning to shift toward user contexts and implementation within the learning process.

Furthermore, the emergence of terms like "human," "teaching," and "education" indicates that the pedagogical dimension remains a crucial component in the development of this research. This means that deep learning technology is not positioned as a standalone entity but rather as part of a learning system involving human interaction. On the other hand, the presence of keywords such as "curricula," "e-learning," and "academic performance" demonstrates a focus on evaluative aspects and the broader development of educational systems. Overall, the patterns emerging from this word cloud reflect a multidimensional research trend, in which technological and pedagogical approaches intersect to shape the direction of deep learning development in higher education.

A tree map visualization illustrating the distribution and proportion of keyword occurrences in research related to deep learning in the context of higher education.

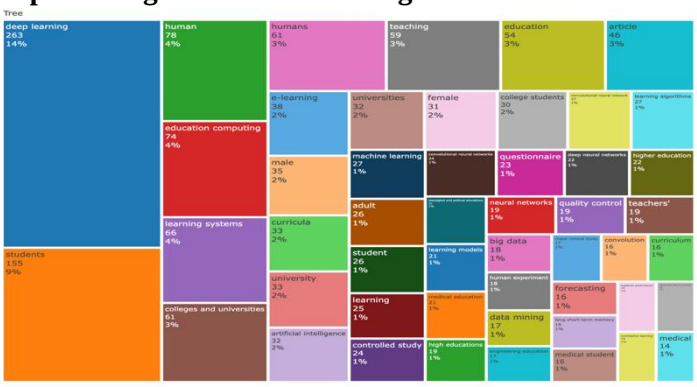

Figure 3. Tree map of deep learning development

Figure 3 presents a tree map visualization illustrating the distribution and proportion of keyword occurrences in deep learning-related research within the context of higher education. From this view, it

is evident that the keyword "deep learning" occupies the most dominant area, affirming its position as the core of the entire study. Below it, terms such as "students" and "human" appear with a significant proportion, indicating that the research focus is not solely on technological development but also on how that technology interacts with users, particularly students as the primary subjects in the learning process.

Furthermore, the presence of keywords such as "education computing," "learning systems," "machine learning," and "artificial intelligence" reflects a strong technical approach in the research, particularly regarding the development of computational systems and models. However, on the other hand, terms such as "curricula," "teaching," "questionnaire," and "quality control" indicate that pedagogical and evaluative aspects also receive significant attention. This indicates that research in this field is developing in an interdisciplinary manner, combining technological perspectives with educational approaches. Furthermore, the emergence of keywords such as "college students," "medical education," and "controlled study" demonstrates an increasingly diverse range of research contexts and subjects. Overall, this visualization reinforces the picture that deep learning research trends in higher education are not moving in a single direction but are evolving through a combination of technological innovation and ever-changing pedagogical needs.

A list of the most prolific authors in publications related to deep learning in the context of higher education during the 2015–2025 period.

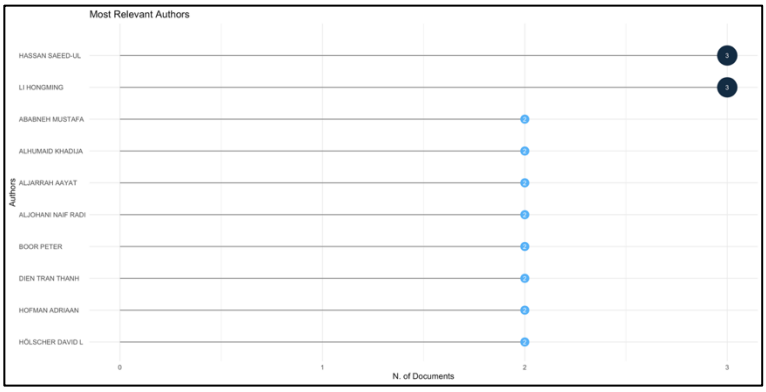

Figure 4. Most Relevant Authors

Figure 4 displays a list of the most contributing authors in publications related to deep learning in the context of higher education during the 2015–2025 period. From this visualization, it is evident that no single author absolutely dominates; rather, contributions are distributed among several authors with relatively similar publication counts. Several authors, such as Hassan Saeed-Ul and Li Hongming, rank at the top with a higher number of publications compared to others, indicating their consistency in researching this topic. Meanwhile, other authors also demonstrate significant contributions, albeit in slightly lower numbers. This pattern indicates that the field of deep learning research in higher education remains open and evolving, meaning that no single dominant group has yet emerged, as is typically the case in more established fields. On the other hand, the diversity of authors also reflects the breadth of academic interest in this topic across various disciplinary backgrounds and geographic regions. This simultaneously opens up broader opportunities for collaboration, as there is no reliance on a specific group of researchers in advancing studies in this field.

The institutions that have contributed most actively to publications on deep learning in higher education.

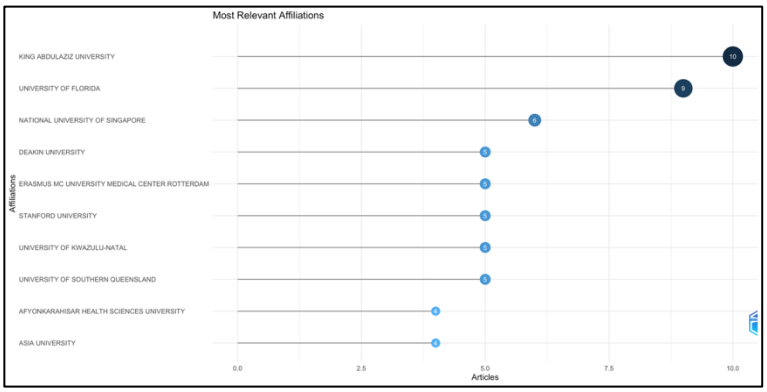

Figure 5. Most Relevant Affiliations

Figure 5 shows the institutions most actively contributing to publications related to deep learning in higher education. It is evident that several universities, such as King Abdulaziz University and the University of Florida, rank at the top with a significant number of publications compared to other institutions. This indicates that certain research centers serve as key drivers in the development of this field. Furthermore, the presence of institutions from various countries demonstrates that research on deep learning is not confined to a single region but has become a global concern. Nevertheless, there is a clear trend showing that institutions with strong research resources and adequate technological infrastructure tend to be more productive in terms of publications. On the other hand, the involvement of institutions from developing countries is also becoming evident, signaling an expansion of participation in the global research ecosystem. Overall, this distribution reflects a combination of concentration and dispersion, where a few institutions serve as major hubs, yet this is balanced by contributions from various other parties.

Distribution of scientific output by country in deep learning research in the context of higher education.

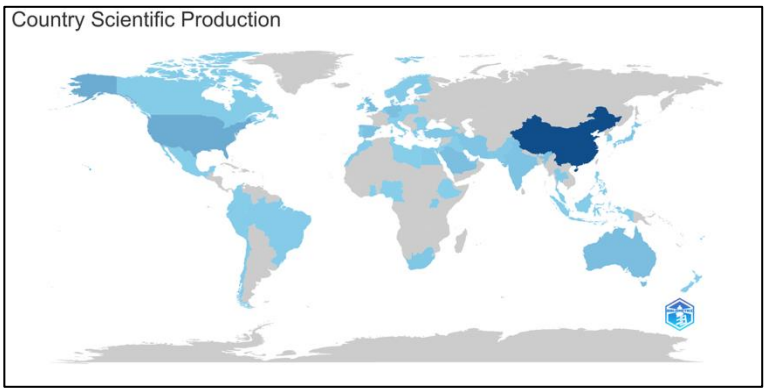

Figure 6. Country-Specific Scientific

Figure 6 shows the distribution of scientific output by country in deep learning research within the context of higher education. From the map displayed, it is evident that countries such as China and the United States make the most significant contributions, as indicated by the darker shading. This indicates that these two countries possess high research capacity, in terms of funding, infrastructure, and an academic ecosystem that supports the development of artificial intelligence technology. Additionally, other countries such as India, the United Kingdom, and Germany also demonstrate significant

contributions, although they remain below the two leading nations. On the other hand, regions such as Southeast Asia, Latin America, and parts of Africa still appear to have relatively limited contributions. This situation reflects disparities in global knowledge production, which are often influenced by factors such as access to technology, research resources, and international collaboration networks. Nevertheless, the emerging contributions from developing countries indicate potential for future growth. In general, this trend indicates that deep learning research in higher education is growing globally, but is still dominated by countries with more advanced technological and research capabilities.

Analysis of Country-Level Output Over Time: Articles on Deep Learning in the Context of Higher Education from 2015 to 2025

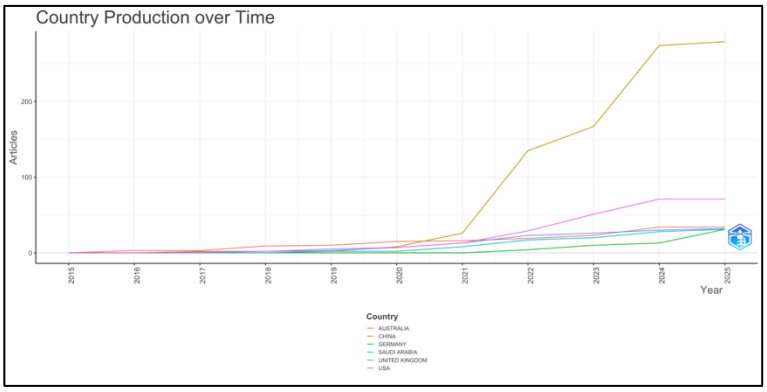

Figure 7. Trends in Scientific Article Production

Figure 7 shows the growth trends in scientific article publications on deep learning in the context of higher education across several major countries during the 2015–2025 period. From the graph, it is evident that China experienced the most significant increase, particularly since around 2020, eventually becoming the country with the highest number of publications by the end of the period. This surge indicates a strong push in the development of artificial intelligence-based research, likely supported by national policies and substantial investments in technology and education. On the other hand, the United States exhibits a more stable and consistent growth pattern year over year. Although it has not experienced a surge as sharp as China's, its contribution remains significant and demonstrates continuity in scientific output. Other countries, such as the United Kingdom and Saudi Arabia, also show an upward trend, particularly in recent years, indicating growing attention to this topic across various regions. Meanwhile, Australia and Germany tend to exhibit a flatter pattern with less pronounced fluctuations, reflecting a stable contribution but no significant acceleration.

Overall, the patterns visible in this graph underscore the existing disparity in scientific output among countries. Countries with strong research support tend to be able to increase the number of publications more rapidly, while others progress at a more moderate pace. Nevertheless, the emerging upward trends in some countries indicate that deep learning research in higher education is growing globally, with the potential for a more even distribution of contributions in the future.

Co-occurrence Analysis of Articles on Deep Learning in the Context of Higher Education from 2015 to 2025

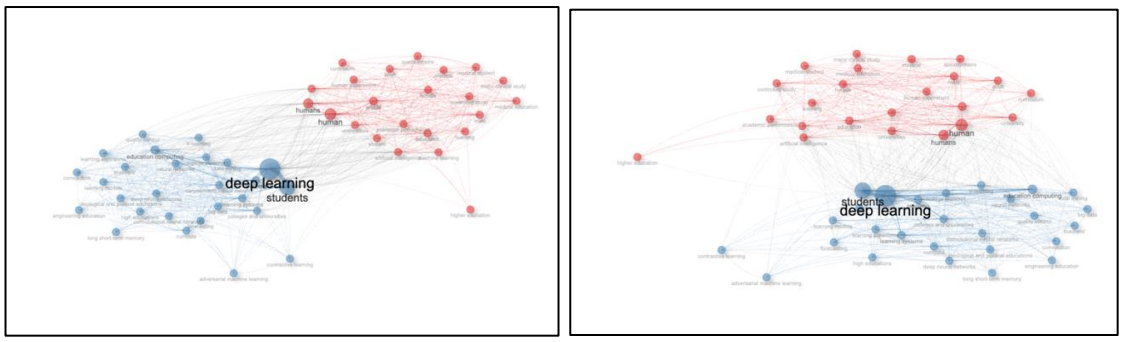

Figure 8. (a) Thematic Cluster Map of Deep Learning Research in Higher Education (b) Keyword Connectivity Structure of Deep Learning Research in Higher Education

Figure 8 presents two complementary visualization methods for illustrating the thematic structure of deep learning research in the context of higher education: a cluster map and a keyword connectivity network. In general, it is evident that research in this field falls into two main trends. On one hand, there is a cluster oriented toward technical and computational aspects, characterized by keywords such as neural networks, learning algorithms, and data mining. This cluster reflects a focus on the development of artificial intelligence-based models and systems. On the other hand, there is a cluster that focuses more on pedagogical and human dimensions, with keywords such as academic performance, human, and education, indicating a concern for the impact of technology on learning processes and outcomes.

When viewed from its connectivity structure, the relationships between keywords in this field appear increasingly dense and integrated. Terms such as “deep learning” and “students” emerge as central nodes with high connectivity, indicating their role as connectors between various research themes. This suggests that although there is a tendency for separation between technical and pedagogical aspects, the two do not develop in isolation but rather intersect and form an increasingly complex knowledge network. Overall, this visualization suggests that deep learning research in higher education is moving toward a more integrative approach, in which technological development and an understanding of the learning context proceed simultaneously and complement one another.

The relationship between journals, authors, and keywords in publications related to deep learning in higher education, as visualized using a three-field plot.

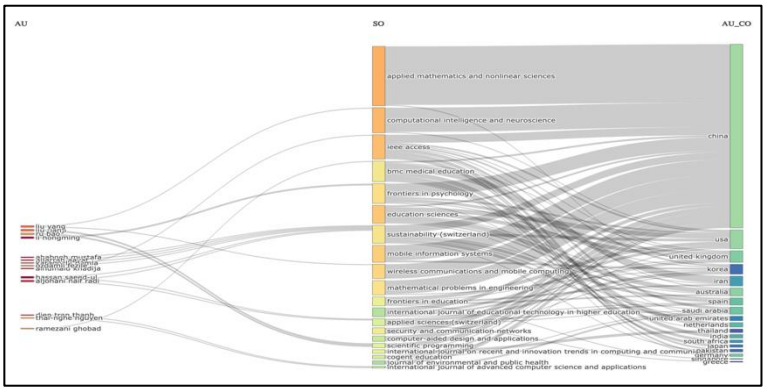

Figure 9. Relationships between journals, authors, and keywords Source: R Bibliometrix

Figure 9 illustrates the relationships between journals, authors, and keywords in publications related to deep learning in higher education through a three-field plot visualization. The figure shows how specific authors are connected to specific journals as well as to the topics or keywords they research. This pattern provides an overview of the publication ecosystem formed in this field, including authors' tendencies in selecting journals and the research focuses they develop. Some authors appear to have strong ties to specific journals, indicating specialization or consistency in their publication trajectories. Additionally, the keywords emerging from this network highlight dominant themes such as machine learning, neural networks, and academic performance, which serve as focal points in the research. Interestingly, these connections also reflect interdisciplinary linkages, where journals spanning technology, education, and the social sciences are interconnected through shared topics.

Overall, this visualization not only shows who is writing where, but also how knowledge in the field of deep learning in higher education is collectively produced, distributed, and developed. This reinforces the view that this field is multidisciplinary and continues to evolve through interactions among authors, publication outlets, and interrelated research themes.

CONCLUSION

This study indicates that the development of deep learning research within the context of higher education has seen a significant increase during the 2015–2025 period, both in terms of the number of publications and the complexity of the topics examined. The results of the bibliometric analysis indicate that scientific contributions are still dominated by countries with strong research and technological capabilities, such as China and the United States, although participation from other countries is beginning to show an upward trend. At the same time, the citation distribution reveals that scientific impact tends to be concentrated in a select number of publications, underscoring the importance of quality and relevance in determining a study's influence.

From a thematic perspective, deep learning research in higher education is evolving along two main trends: a technical approach focused on the development of artificial intelligence systems, and a pedagogical approach emphasizing its impact on learning processes and outcomes. These two approaches do not operate in isolation but are increasingly demonstrating a close interconnection as the need for adaptive, data-driven learning systems grows. Overall, these findings confirm that deep learning functions not only as a technological innovation but also as part of a paradigm shift in higher education. Therefore, future research should be directed toward strengthening the integration of technological and pedagogical aspects, as well as fostering cross-institutional and cross-national collaboration to create a more inclusive and sustainable learning ecosystem.

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