Scientific Mapping of Research Evolution on Artificial Intelligence in Education: A Scientometric Analysis

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Abstract:

This scholarly study presents a comprehensive research publication and citation trends on Artificial Intelligence in Education (AIEd). For this study, the bibliometric analysis method was used. A total of 7,732 documents were extracted with the help of PRISMA (2021) guidelines from the Lens database, published from 2000 to 2024 as of October 14, 2024. Quantitative data analysis and scientific mapping were conducted using MS Excel (2021) and VOSViewer (version 1.6.20) software. The findings of this investigation indicated that the publications in the field of AIED emerged before 2000; however, a significant surge was noted after 2018. Maximum publications (N = 2252) on AIED were found in 2024, and the maximum number of citations (N = 21728) was recorded in 2023. Approximately 84% of publications (N= 6476) were published as Journal articles. The most productive country is the USA. The most common keyword used in the AIED domain was 'Artificial Intelligence', which has 1954 occurrences. This paper will be helpful for the scientific community as well as novice researchers. This paper provides a global lens on AIED-related publications over time.

Keywords: Artificial Intelligence, Bibliometric analysis, Research evolution, and Scientific visualization.

Introduction:

Artificial Intelligence (AI) constitutes a specialized domain within computer science that employs algorithms and machine learning methodologies to emulate or replicate human cognitive functions (Helm et al., 2020). Scholarly literature indicates that the application of artificial intelligence technology within the educational sector encompasses at least ten distinct dimensions: "the (i) automated grading system, (ii) reminder intervals, (iii) feedback from instructors, (iv) virtual educators, (v) customized learning experiences, (vi) adaptive educational methodologies, (vii) augmented and virtual reality, (viii) precise reading capabilities, (ix) intelligent campus systems, and

(x) remote learning modalities" (Yufei et al., 2020). Within the educational framework, AI generally pertains to a collection of technologies that empower machines to execute tasks traditionally associated with human intelligence, including speech recognition, decision-support mechanisms, and problem-solving capabilities. Both students and educators engage with generative AI to produce and consume content pertinent to academic assignments (Baidoo-anu & Ansah, 2023). The integration of AI technologies within educational environments is presently being implemented across diverse educational contexts to augment the processes of teaching and learning, yielding advantages such as individualized instructional approaches, wherein AI is utilized to tailor the pace, content, and assessment methodologies to the specific needs of learners (Chiu et al., 2022). Additionally, AI has assisted educators by automating routine administrative functions and grading processes, enabling them to concentrate on more intricate pedagogical strategies and foster greater engagement with students (Ahmad et al., 2022). This advancement ensures that more students are afforded access to high-quality educational experiences, irrespective of their geographical circumstances (Alam, 2021). Current AI technologies utilized within classroom settings primarily concentrate on supporting individual students or teachers, which may inadvertently lead to the isolation of students and impede collaborative efforts and teamwork. Nevertheless, a nascent domain of research and innovation is emerging that emphasizes human-AI collaboration, in which AI technologies are structured to operate synergistically with human educators and students. While AI is progressively being adopted across various industries, facilitating workers in automating manufacturing operations, assisting in educational endeavors, and amplifying human creativity (Marrone et al., 2022), its incorporation into human collaborative teams remains a developing area that necessitates further exploration and investigation. As AI technology continues to advance, its assimilation into team-oriented environments is poised to escalate within the workforce, underscoring the imperative for students to cultivate human-AI collaboration competencies for their prospective achievements (Zhang & Villanueva, 2023; X. Zhang, 2021).

Bibliometric analysis has emerged as a significant field of scholarly inquiry. The evolution and interrelations among bibliometric indicators are effectively elucidated through quantitative methodologies utilizing available scholarly texts ((Wang et al., 2021). A thorough examination of pertinent literature is an invaluable approach for evaluating the productivity and global interconnections of academic journals or topics. Bibliometric analysis represents a well-established and efficacious statistical methodology grounded in quantitative assessment, which endows researchers with the capacity to present a holistic overview from an international perspective (Jia et al., 2024). The domain of bibliometric research has evolved over an extensive period and has

culminated in numerous remarkable scientific accomplishments. According to (Broadus, 1987), bibliometrics is "the quantitative examination of tangible published entities, bibliographic units, or their corresponding surrogates." Bibliometrics is described as "one of the rare truly interdisciplinary research domains that permeate nearly all scientific domains" (Glänzel, 2003). Co-author analysis assesses the social networks researchers construct through collaborative endeavors in scientific publications (Acedo et al., 2006). This examination of co-authorship is particularly proficient in addressing research questions related to scientific collaboration (Pal et al., 2025; Pal & Kumar, 2025).

Research Objectives:

The most important objective of this research study was to present the evolution of AIEd research. The bibliometric analysis and scientific visualization of the published studies conducted in the context of various dimensions of AI in education were analyzed. The other objectives of this study were to find out the top-producing countries, authors, and sources in the field of AI in education.
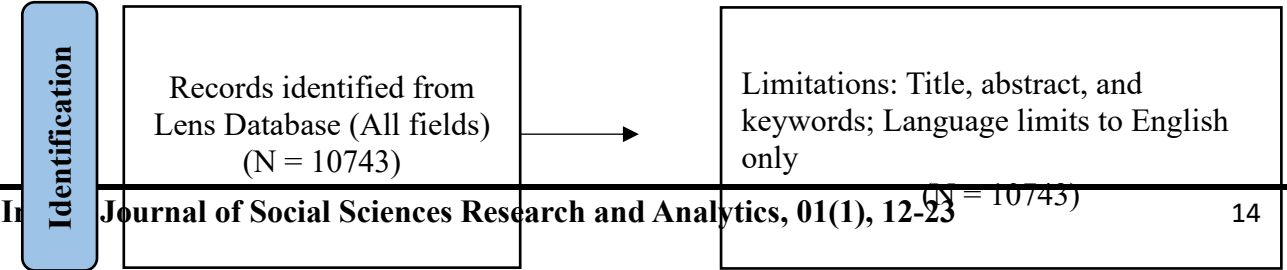
Methods and Materials:

A bibliometric analysis method was used in this study. A total of 7732 relevant publications have been analyzed. The reported CSV file was extracted from the Lens database (https://www.lens.org/) by searching "Artificial Intelligence in Education". The VOSviewer (version 1.6.20) and Excel (2021) software have been used for analysis and results visualization. The author follows the PRISMA (Page et al., 2021) Guidelines for data extraction. The PRISMA flowchart, by which the author extracted the data file, is presented in Figure 1.

Results and Discussions:

Over Time Publications on AIEd:

A total of 7732 studies have been published (as of 14/10/2024 4:30 PM), available on the Lens database, related to AI in education. The total number of studies is presented in Figure 1 by dividing them into different periods. It is clear from the observation of Figure 1 that there has been a significant increase in the number of publications on AI in education on the Lens database after 2018. The highest (2252) publication took place in the year 2024, and the lowest (10) in 2002. The year-wise publications are presented in Figure 2.

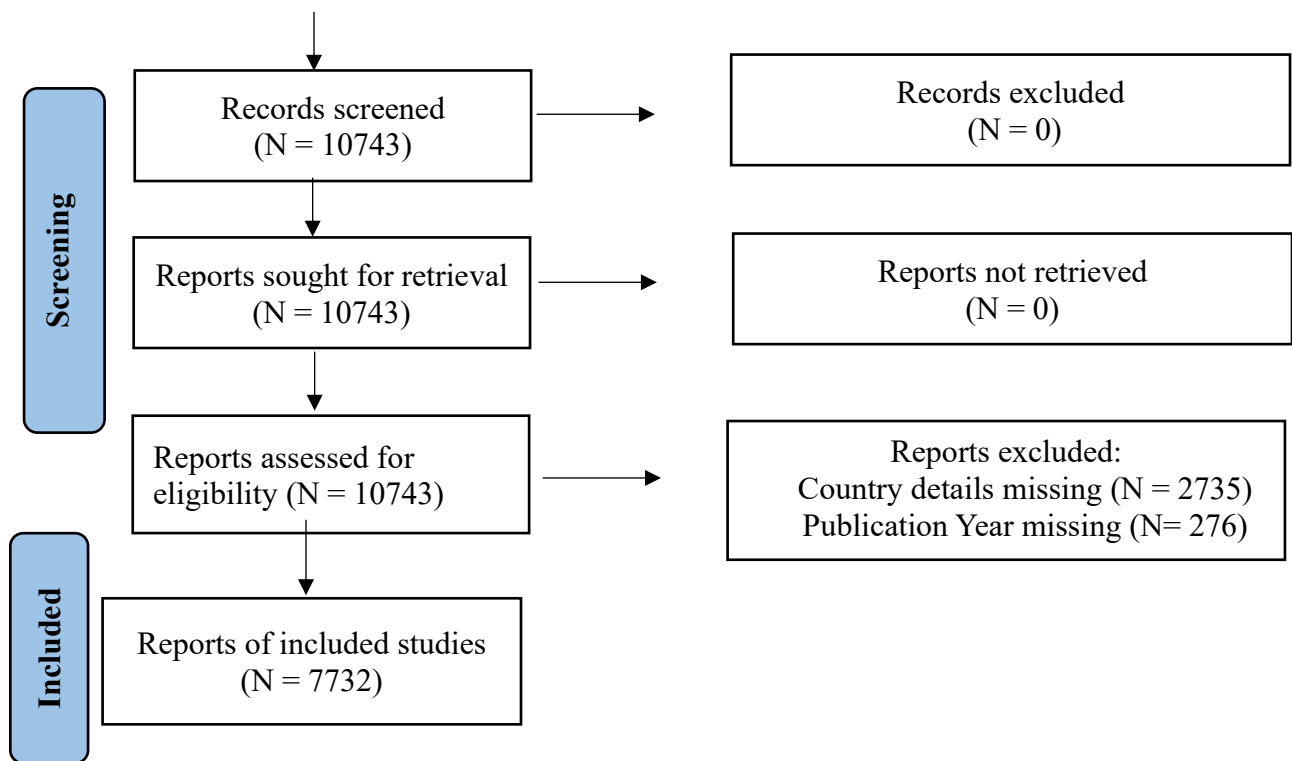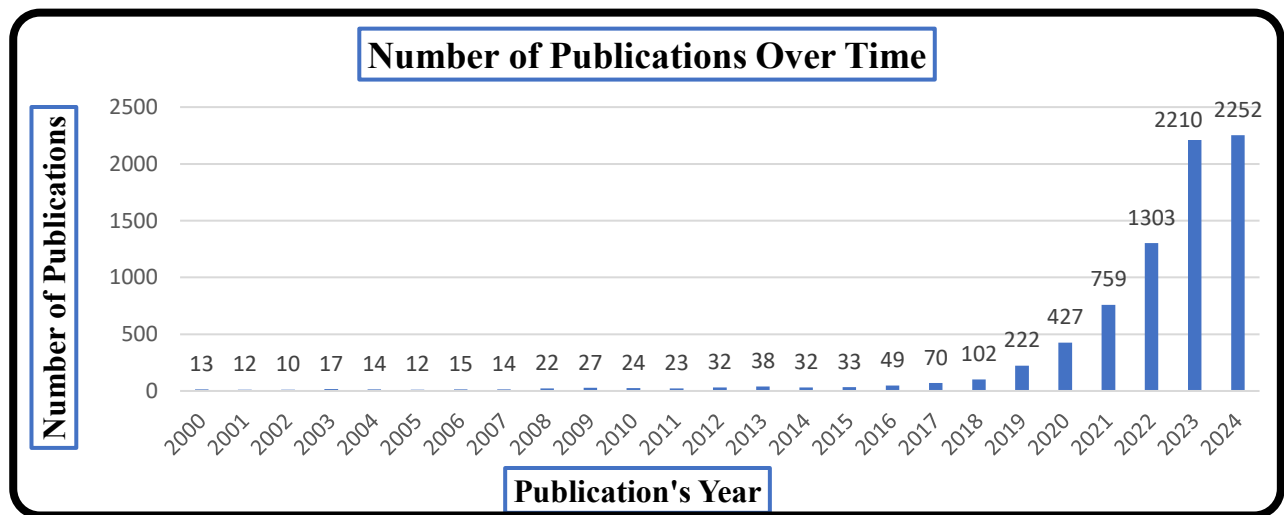**Figure 1: Identification of studies on AIEd from lens database**

Identification

Records identified from Lens Database (All fields) (N = 10743)

Limitations: Title, abstract, and keywords; Language limits to English only (N = 10743)

Records screened
(N = 10743)

Records excluded
(N = 0)

Reports sought for retrieval
(N = 10743)

Reports not retrieved
(N = 0)

Reports assessed for
eligibility (N = 10743)

Reports excluded:
Country details missing (N = 2735)
Publication Year missing (N= 276)

Reports of included studies
(N = 7732)

Screening

Included

Figure 2: Publication trends on AIEd

Number of Publications Over Time

Number of Publications (Y-axis): 0, 500, 1000, 1500, 2000, 2500

Values by year: 2000: 13, 2001: 12, 2002: 10, 2003: 17, 2004: 14, 2005: 12, 2006: 15, 2007: 14, 2008: 22, 2009: 27, 2010: 24, 2011: 23, 2012: 32, 2013: 38, 2014: 32, 2015: 33, 2016: 49, 2017: 70, 2018: 102, 2019: 222, 2020: 427, 2021: 759, 2022: 1303, 2023: 2210, 2024: 2252
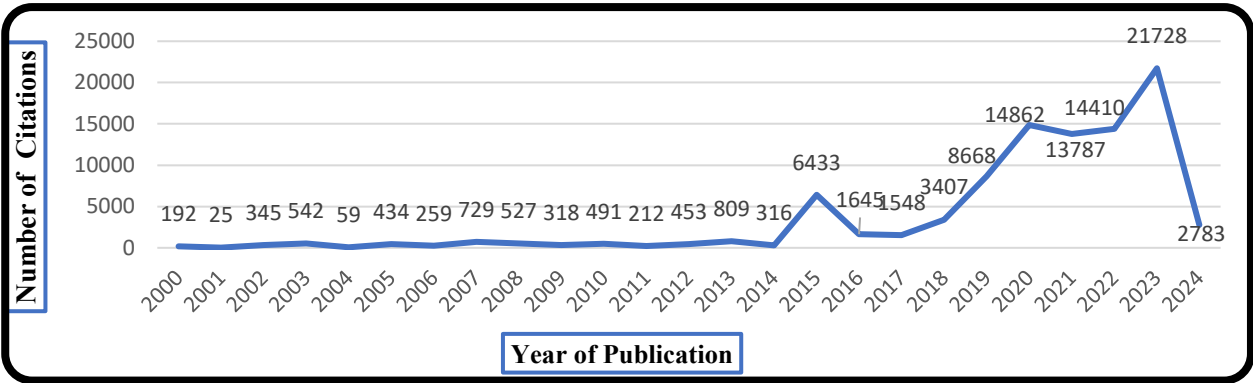
Publication's Year

Source: Created by Author

Citation Trend of Publications on AIEd:

In Figure 2, the author presents the citation trend of research on AIEd over time. From the perusal of Figure 2, it is clear that AIEd-related publications received huge citations after 2014. The maximum (N= 217280) number of citations received in 2023, while the lowest (N= 25) was in 2001. Year-wise citations can be seen in Figure 3.

**Figure 3: Citation Trend of Publications on AIEd**

Source: Created by Author

Details of Document Type-wise Publications:

A total of 7732 documents were published in various types of documents. The details of various types of documents are presented in Figure 3. From the perusal of Figure 3, it is clear that the maximum number of publications (N= 6476) is published under the journal article category. Details of Documents' Type-wise Publications can be seen in Figure 4 below:

Figure 4: Documents' Type-wise Publications
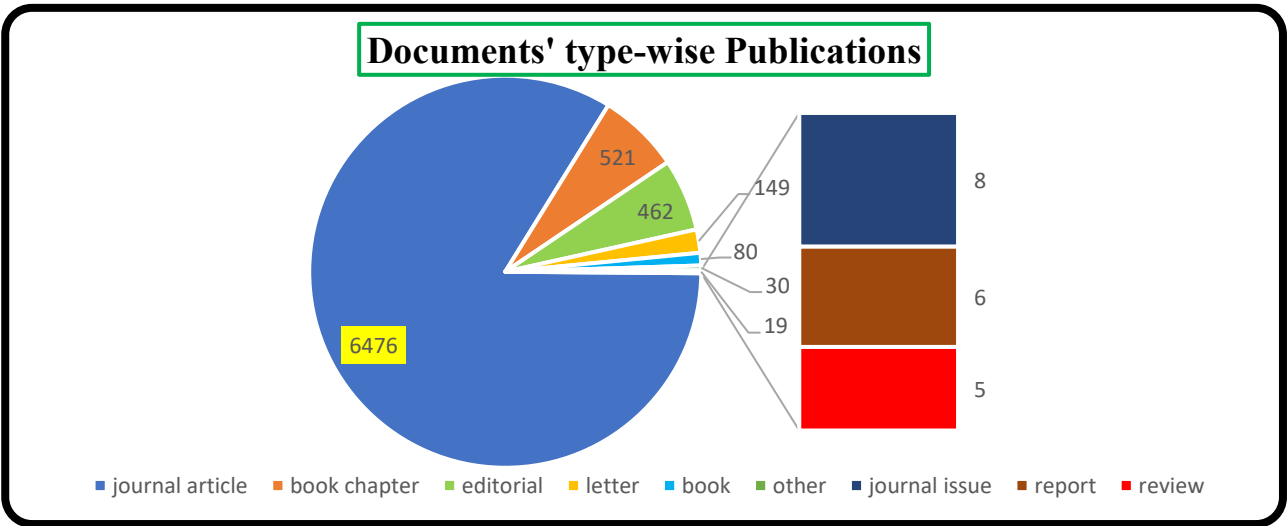
Source: Created by Author

Top 10 research-producing countries:

For the analysis of the top 10 research-producing countries on AIEd, the author set the criterion of at least 60 publications per country; after that, the top 10 productive countries were found. The top 10 AIEd-related research-producing countries out of 69 are presented in Table 1 below:

Table 1: Details of the Top 10 Productive Countries

Ranks	Country	Documents	Citations	Citations/Document	Citations/Year
1.	United States	2315	23292	10.06	931.68
2.	United Kingdom	1760	23012	13.08	920.48
3.	Netherlands	889	8298	9.33	331.92
4.	Germany	854	11609	13.59	464.36
5.	Switzerland	520	8158	15.69	679.83
6.	Egypt	243	4149	17.07	377.18
7.	Canada	227	3251	14.32	270.92
8.	India	112	753	6.72	68.45
9.	England	81	742	9.16	92.75
10.	France	60	602	10.03	75.25

Source: Created by Author

From the Perusal of Table 1 above, it is clear that the United States of America (USA) is the top research-producing country on AIEd. The USA has published 2315 documents from 2000 to 2024 in the field of AIEd. The publications published by the USA in the field of AIEd have received 23,292 citations over time. The citations per document and year of the USA are 10.06 and 931.68, respectively. Similarly, the lowest publications (N=60) has been published in France. India has published 112 articles on AIED from 2000 to 2024. India has received 753 citations in their publications. In this way, the details of other top productive countries can be seen in Table 1.

Co-authorship Analysis:

The VOSviewer software facilitates the construction of a network, density, and overlay visualization map of authors on the similarity of their publications by utilizing the 'co-authorship' options. The magnitude of the sphere within the network visualization map indicates the number of publications attributed to the corresponding author. The analysis of co-authorship provides a total of 25095 authors by running the co-authorship option with the unit of analysis (authors) of the VOSviewer software. After fitting the criteria of at least three documents and at least 3 citations, 588 thresholds were found. Only 74 authors connected out of 588 thresholds. Their collaboration Network Visualization Map shows the most extensive set of connected authors. These 38 connected authors created 3 clusters and 337 links. The total link strength of mostly connected authors is 338.

Top 10 Productive Authors:

A total of 10 highly productive authors were identified from the dataset, which was generated by establishing a minimum criterion of 10 publications and a threshold of at least 1 citation within the co-authorship option to analyze the foremost productive authors in the field of AIEd. These top 10 authors created 9 distinct clusters and established only one interconnection (link). The aggregate strength of these connections is 4. The details regarding the top 10 authors selected from a total of 25095 authors are delineated in Table 2 below:

Table 2: Top 10 Productive Authors in AIEd

Ranks	Authors	Documents	Total citations	Citations/ document	Citation/Year
1.	Null Null	30	144	4.80	48.00
2.	Ishith Seth	13	158	12.15	79.00
3.	Linda Moy	13	340	23.07	113.33
4.	Ching Sing Chai	11	53	4.81	10.60
5.	Ig Ibert Bittencourt	10	685	68.50	228.33
6.	Jiahong Su	10	167	16.70	55.66
7.	Thomas K. F. Chiu	10	164	16.40	54.66
8.	Mutlu Cukurova	9	162	18.00	81.00
9.	Tien Yin Wong	9	507	56.33	169.00
10.	Zhonggen Yu	9	502	55.77	251.00

Source: Created by Author

Top 10 Productive Sources:

A total of 7732 documents have been published by 2428 sources. For the analysis of the top 10 sources, the researcher set the criteria of at least 68 publications and at least 237 citations; after that, the top 10 sources were found. These top 15 sources created 3 clusters and 32 links, and the total link strength is 368. Lecture Notes in Computer Science is the most productive source, with a total of 199 publications and 1110 citations. Similarly, the details of the other top sources can be seen in Table 3 below:

Table 3: Details of Top Productive Sources

| Source	Documents	Citations	Citations/ Document
Lecture Notes in Computer Science	199	1110	5.58
Journal of Physics: Conference Series	157	477	3.04

Radiology	152	2099	13.81
Sustainability	124	3111	25.09
Communications in Computer and Information Science	121	237	1.96
Education and Information Technologies	112	1659	14.81
Cureus	94	784	8.34
Frontiers in Psychology	76	979	12.88
Journal of Medical Education	73	2312	31.67
International Journal of Artificial Intelligence in Education	68	2153	31.66

Source: Created by Author

Co-occurrence Analysis of Keywords:

The co-occurrence of keywords indicates research themes within academic disciplines, offering supplementary assistance to scholarly investigations (Li et al., 2016). A network illustrating the co-occurrence of keywords pertinent to AIEd was constructed utilizing VOSviewer software. Figure 6 presents a graphical representation of the most frequently utilized keywords in AIEd-related publications over time. The 'Co-occurrence with the unit of analysis- All keywords' feature was implemented using VOSviewer software to explore the keywords used in AIEd-related publications. A total of 6676 keywords were used in 7732 documents. A density visualization map, which shows the density of occurrences of keywords used in AIEd-related publications, can be seen in Figure 5 below:

Figure 5: Density Visualization Map of Keywords
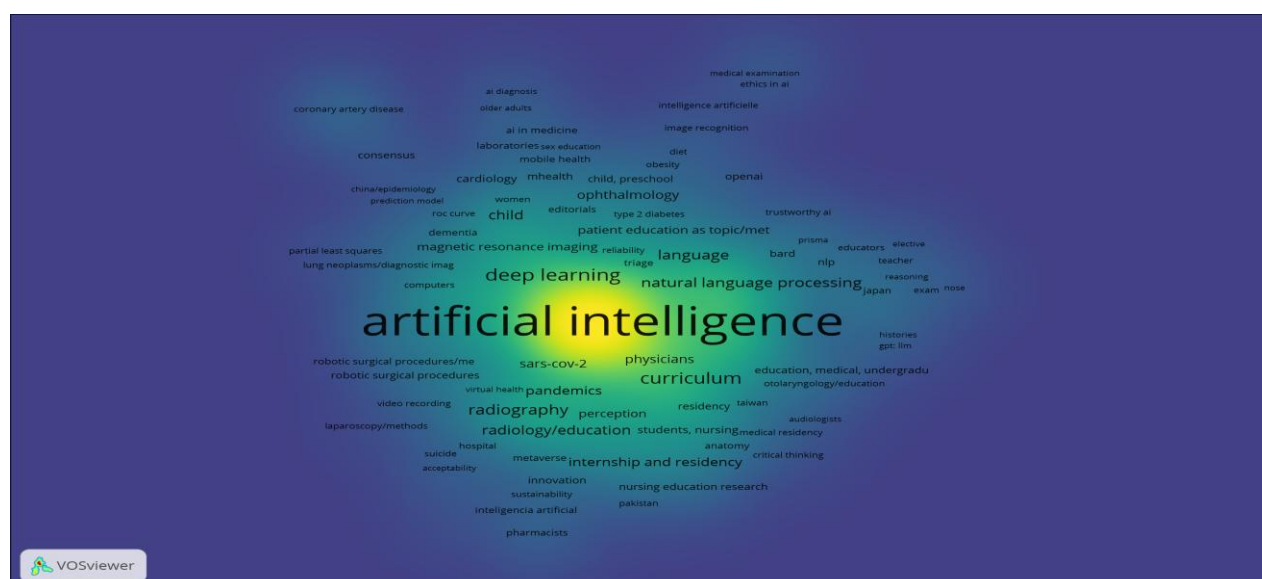
Top 10 Keywords:

From observing the keyword density map in Figure 6 above, it is clear that AIEd is closely related to various disciplines of scientific knowledge at the global level. Most occurrence keywords were analyzed with the help of VOSviewer software by increasing the order of their occurrence criteria; following this analytical process, the top 10 keywords exhibiting the highest frequency were identified, based on a minimum threshold of 146 occurrences. The top 10 keywords, with Total occurrences, links, and their total link strength, are presented in Table 4 below:

Table 4: Top 10 Keywords

Keyword	Occurrences	Total Link Strength
Artificial Intelligence	1954	2801
Humans	1797	2465
Machine Learning	328	709
Chatgpt	299	588
Education	277	546
Female	203	607
Medical Education	200	444
Male	179	574
Deep Learning	169	317
Curriculum	146	379

Source: Created by Author

From the perusal of Table 6 above, it is clear that 'Artificial Intelligence' is the most popular keyword with maximum (N=1954) occurrences. Its total link strength is 2801. The second and third most popular keywords are Humans (N=1797 occurrences) and Machine Learning (N=328 occurrences). Similarly, some occurrences and total link strength of other top keywords can be seen in Table 4 above. These top 10 keywords are well-connected. They create 3 clusters and 100 collaboration links; their total link strength is 6502. The network visualization map of collaboration links of these keywords is presented in Figure 6 below:

Figure 6: Network visualization map of the top 10 keywords
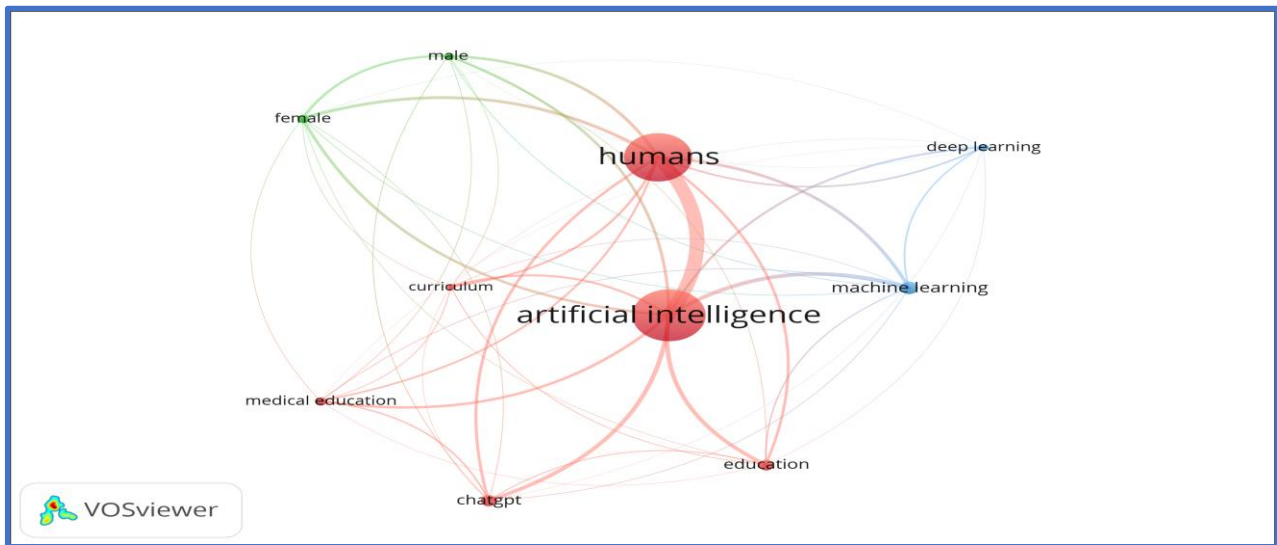
Conclusion:

This study analyzes and highlights over time publications, on the AIEd from 2000 to 2024. The dominance of the keyword "Artificial Intelligence" in the literature is evidenced by its 1954 occurrences. The highest number of publications was found in 2024, and the maximum number of citations was recorded in 2023. The maximum number of publications was found in the journal article type of documents. The study also reveals the significant contributions of authors from the nations, the USA, with the highest research output. This work is done with the data extracted from only the lens database. Future research should consider using multiple databases and expanding search terms to capture a more comprehensive and diverse range of scholarly works on AIEd. Additionally, qualitative studies explore the experiences and perspectives of educators, students, and other stakeholders involved in the field of AIEd.

Acknowledgement:

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