

Intelligent Learning: A Bibliometric Review of AI Integration in Modern Educational Practices

Bahja A. Al-Mubarak, Hafiza Abas, Sya Azmeela Shariff

Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia - UTM Kuala Lumpur, 54100 Kuala Lumpur

Email: bahjamubarak@gmail.com, hafiza.kl@utm.my, azmeela.kl@utm.my, abdulhadishaikh@live.utm.my

Corresponding Author Email: bahjamubarak@gmail.com

To Link this Article: <http://dx.doi.org/10.6007/IJARBSS/v14-i4/21328>

DOI:10.6007/IJARBSS/v14-i4/21328

Published Date: 16 April 2024

Abstract

The main objective of this work is to investigate the relationship between the integration of artificial intelligence in education in the pre- and post-pandemic period, as well as the apparent impact on educational practises. This bibliometric study uses the PRISMA framework to summarise works that relate the integration of artificial intelligence to contemporary educational methods. Scopus was selected for its comprehensive coverage and excellent reputation as a resource for analysing scholarly articles, as was Vosviewer for its extremely useful graph displaying data links from the database. Inclusion and exclusion criteria were used to reduce the results to 3,010 relevant publications. The inclusion of modern technologies, such as artificial intelligence, in education has become not only a trend but also an absolute necessity. This transition is reflected in the emphasis on research. The list of prominent publications, nations and groups contributing to this problem shows that they are influential worldwide. The study focuses on the most prolific authors and key research keywords, highlighting the transdisciplinary nature of research in machine learning and education. Education is no longer the same after the pandemic, as the increasing number of publications by different authors shows. Various teaching and learning methods are presented, with a focus on numerous technology-based solutions, particularly artificial intelligence applications and platforms. The publications on this topic and the keywords show how collaborative and diverse research in this area is. Continued research is essential for the design of educational techniques and the improvement of learning experiences in the context of digital platforms and artificial intelligence applications. The paper recommends more intensive research to improve digital education and learning methods. To understand, compare and improve the impact of AI applications and platforms on learning outcomes, continuous developments and techniques are needed to expand the scope of knowledge.

Keywords: Artificial Intelligence, Education, Machine Learning, Students, Learning System.

Introduction

The use of artificial intelligence and machine learning in academic writing and learning is currently experiencing an international upsurge, proving to be an integral part of education as it began as a solution to the pandemic-induced shutdown in 2019 and 2020, when academic institutions were forced to close their physical doors and utilise the available applications of electronic learning (Niemczyk, 2021). From then on, the production of higher quality virtual educational spaces increased, and educators developed advanced methods for learning and teaching that included artificial intelligence applications and processes and enabled different ways of transferring information and learning outcomes. According to (Yang et al., 2020), the AI approach was used to provide customised learning and intelligent push services. This approach enabled the online platforms to easily incorporate teaching information into individual teaching situations, while the offline cloud platform handled the teaching process in an intelligent way.

Zeng et al (2020) argued that this accelerating change has helped artificial intelligence solutions technologists create a trend where educational institutions compete for the high-tech foundations and databases they need to implement and operate with fewer resources and lower costs, and most importantly, to reach more people, learners and scholars. Understanding new technologies and learning methods used by educators is critical to creating and maintaining quality assurance relationships in educational institutions (Abuhassna et al., 2022a). Self-learning and machine learning are becoming increasingly important, opening up new dimensions for learning outcomes, automated assessments and virtual learning spaces. Khan and Bose (2021) emphasise that the primary goals of using AI in education are to innovatively use existing digital technology for learning and to improve traditional educational methods through modern teaching methods.

The need for a comprehensive understanding of the intricate relationship between the integration of artificial intelligence and education in the post-COVID-19 era is the basis of this review. The aim of this bibliometric analysis is to undertake a thorough examination of the many implications of the integration of artificial intelligence solutions into modern educational practise, with a focus on identifying trends, patterns and shortcomings in the current body of research. The main objective of this study is to provide a comprehensive synthesis of the relevant academic literature that offers a nuanced perspective on the impact of artificial intelligence applications on academic practises. This study aims to make a scholarly contribution to the ongoing debate on artificial intelligence by examining the quality of learning outcomes in education and proposing pedagogical practises that are rigorous and have a positive impact on education as a whole. The aim of this bibliometric study was therefore to provide answers to the following research questions:

- What is the distribution of AI integration in publications on education in the years 2016–2022?
- Which academic publications are most relevant to the study of AI integration in education?
- Which countries have had the greatest impact on the integration of AI in education research?
- Which educational institutions have made the most notable contributions to the study of AI integration in education?

- Which authors have made the most notable contributions to the study of AI integration in education?
- Over the past seven years, what have been the most notable research foci related to the integration of artificial intelligence in education?

Methods

Research Design

This bibliometric analysis is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Moher et al., 2010). The aim of this review was to examine the relationship between the integration of AI in education, the top countries, the top educational institutions, the top journals, the most prolific authors, and the most trends and keywords in this area of research. In addition, Mishra and Mishra (2023) found that the (PRISMA) framework helps authors to improve their reporting and reviewers and editors to critically evaluate accessible systematic reviews.

In addition to the PRISMA framework used for this bibliometric analysis, VosViewer was used extensively in this study for data visualisation and analysis. According to Hassan Abuhassna, et al. (2022b), VosViewer is a software programme that facilitates the creation and analysis of bibliometric networks. These networks can consist of journals, publications, scientists or even individual works. The networks are then created based on links such as co-authorship, citation, co-citation and bibliographic linkage (Orduña-Malea & Costas, 2021). VosViewer greatly facilitated the mapping and analysis of the different networks that make up the digital learning research in our study. It helped to understand the relationships between different academic fields, to identify key journals, publications and authors, and to graphically visualise trends. The software's interactive graphical user interface and ability to process large amounts of information enabled thorough data analysis. This supported the study's investigation and led to the identification of key trends and patterns related to educational research. Through the geographical organisation of publications and collaboration between institutions and authors, VosViewer provided a broader overview of the global impact and research dynamics around the integration of artificial intelligence in education.

Identification

- Database Selection

This review analysis was conducted on 17 December 2023 and the Scopus database was used as the primary database. Scopus was selected because it is one of the most trusted sources of information for examining scientific publications from a variety of disciplines.

- Search Strings

To ensure the retrieval of the studies selected, the researcher used exact key words, these keywords were "(AI and education", for instance TITLE-ABS-KEY (Artificial AND intelligence AND education). Moreover, publications for the last seven years were selected from 2016 to 2022, for instance "AND PUBYEAR > 2015 AND PUBYEAR < 2023 AND PUBYEAR > 2012 AND PUBYEAR < 2023 AND". In addition, subject area was limited to computer science, social science, business, management and accounting and arts and humanities, for instance (LIMIT-TO (SUBJAREA, "COMP") OR LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ARTS"). Publication in English were selected in this review, AND (LIMIT-TO (LANGUAGE, "English"). Publications were limited to conference papers and

articles only as these are more relevant to the topic which is considered as new and controversial AND (LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ar")).

- Inclusion and Exclusion Criteria

The search focuses only on English-language publications from 2016 to 2022 to illustrate the degree of integration of artificial intelligence before and after the pandemic period, which has triggered a change in machine learning and its applications in many aspects and disciplines, especially in education, for this research. Conference papers and articles are included in this research as the topic area is current and there is an opportunity to include the latest contributions and research from emerging scholars interested in the field of this study.

Table 1

Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Artificial intelligence in education research area	Any other subjects were excluded.
2016 – 2022	All publications before 2016 were excluded. And 2023 publications were excluded.
English language	Any other languages
Conference papers and Articles	Thesis, books, book chapters blogs.

Screening and Selection

The main keywords used were “AI and education”, so the initial search returned 9,308 documents. After applying the inclusion and exclusion criteria, as shown in Table 1, the publications were reduced to 3,010 as the final search, as 6,298 were excluded.

Inclusion and Reporting

The results of this bibliometric analysis are reported based on the PRISMA framework (see Figure 1). (Moher et al., 2010). Thus, the following section addresses the questions posed in the research.

Methods

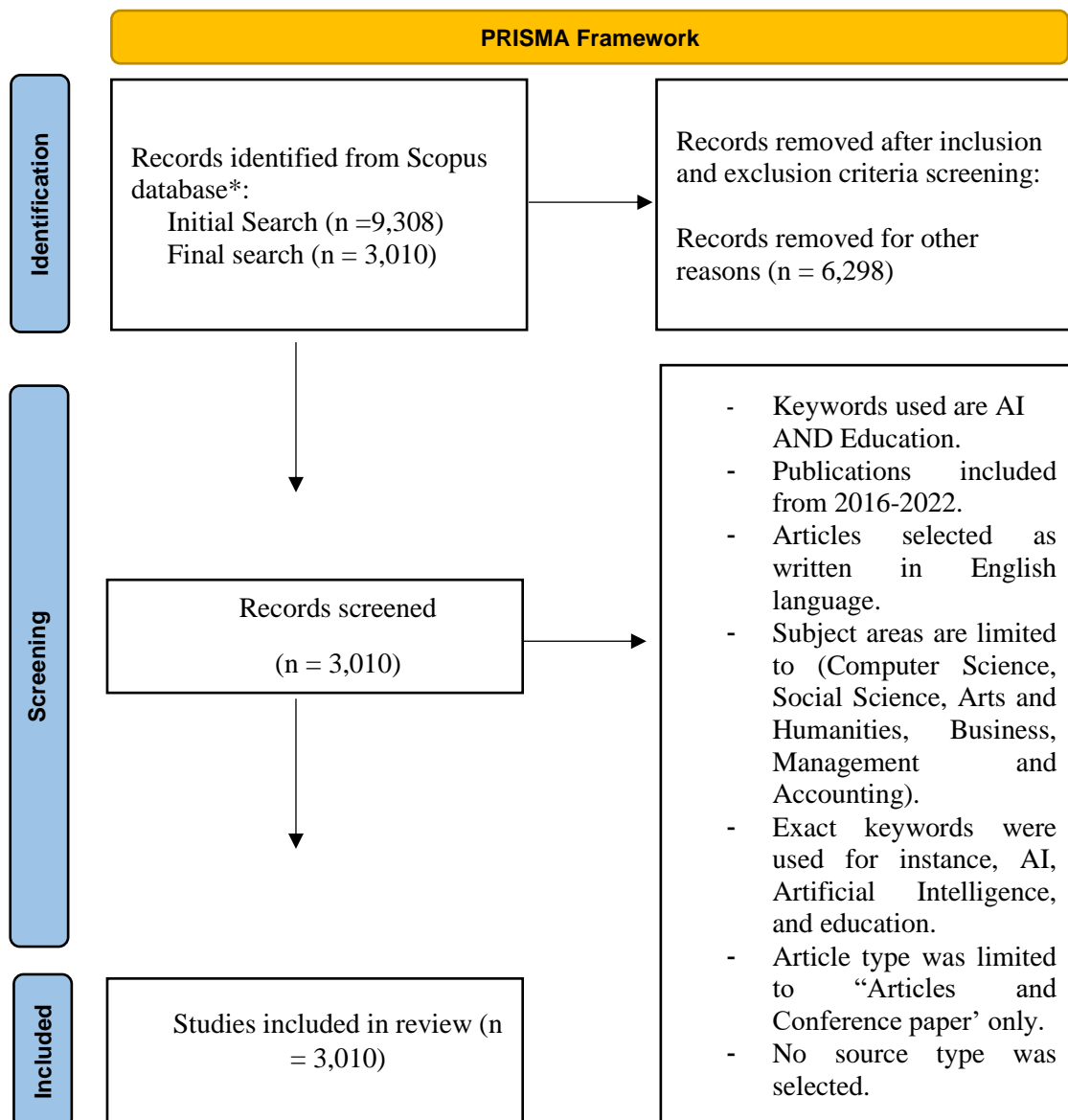


Figure 1 - PRISMA Framework for this review

Results

This section presents the results of a bibliometric analysis of the relationship between the integration of artificial intelligence and education. The study provides insightful information on various facets of this ever-changing field and spans seven years of research. It covers prominent subject areas, publication trends, major countries and journals, key academic institutions, prolific authors and primary research keywords. The aim of this summary is to outline the evolution of the technology and applications of AI research, identify the key elements driving academic research, and provide a comprehensive overview of global efforts to understand the impact of virtual learning environments on education. The primary research questions are discussed by the researcher in this section.

The distribution by years

This section addresses the following research question: "What is the distribution of AI integration in educational publications in the years 2016–2022?" By analysing the data provided, we can answer the first study question about the distribution of AI integration in education from 2016 to 2022. According to the data, the number of publications on AI integration in education has increased significantly over time, especially after 2019. The number of publications has steadily increased each year.

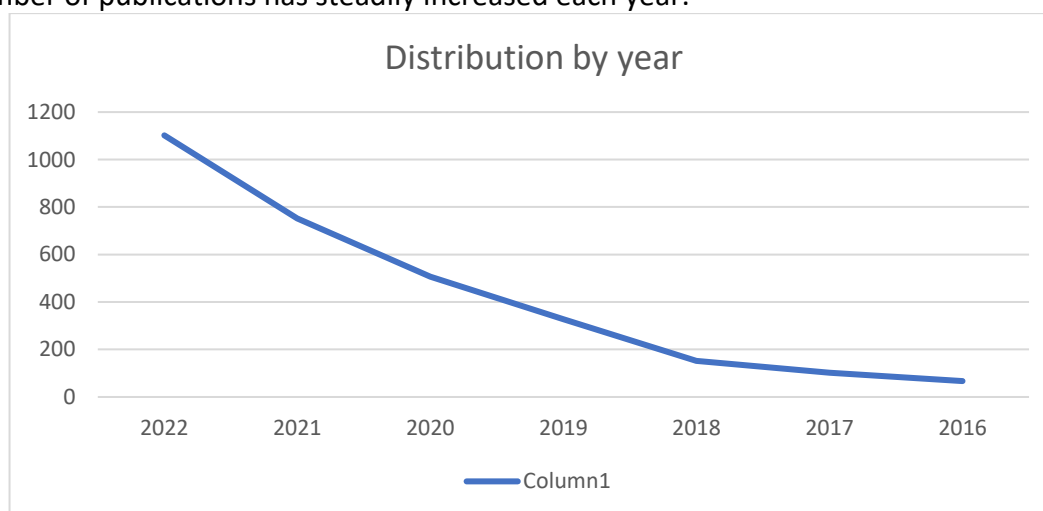


Figure 2 - The Distribution by Year

Figure 2 shows the distribution of AI integration in publications on the topic of education in the period from 2016 to 2022. The largest number of articles appeared in 2022 with around 1102 publications, compared to 752 publications in 2021.

In contrast, the number of publications in the field of artificial intelligence in education did not exceed 67 in 2016. The shift in interest in this field of research began in 2018 with 152 publications, which increased dramatically in the following years: 327 publications in 2019, 507 publications in 2020 and so on, resulting in a huge increase in publication numbers that reflects the importance of the integration of AI in education. The reasons for this change are explored in more detail in the following section.

The most relevant journals and authors

This section addresses the second research question: Which academic papers are most relevant to the study of the integration of artificial intelligence in education? Table 2 shows a

number of articles that make important contributions to this area, based on data from the top ten journals in the field of AI integration in education research from 2019 to 2022.

Table 2

Top 10 Journals in AI Integration in Education Research

Journal name	TP (2019-2022)	TC (2019-2022)	Cite Score (2022)	Most cited article	Times cited	Publisher
ACM International Conference Proceeding Series	45,524	49,408	1.1	The robots are coming: Exploring the implications of OpenAI codex on introductory programming	73	ACM Digital Library
Lecture Notes in Computer Science	79,131	174,042	2.2	ByteTrack: Multi-object Tracking by Associating Every Detection Box	151	Springer Nature
CEUR Workshop Proceedings	20,633	23,405	1.1	FACTIFY: A Multi-Modal Fact Verification Dataset	22	Paper with Code
Advances in Intelligent Systems and Computing - Discontinued on Scopus- as of 2019	29,624	26,852	0.9	2021 - Diabetic Retinopathy Detection Using Transfer Learning and Deep Learning 2020 - Deep Learning vs. Traditional Computer Vision 2019 - Moving statistical body shape models using blender	98 497 444	Springer Nature
Sustainability	48,515	281,274	5.8	A Global Assessment: Can Renewable Energy Replace Fossil Fuels by 2050?	182	Multidisciplinary Digital Publishing Institute (MDPI)
Communications in Computer and Information Science	23,175	22,972	1.0	A Deep Learning-Based Intrusion Detection Technique for a Secured IoMT System	24	Springer Nature

Lecture Notes in Networks and Systems	25,876	18,888	0.7	Machine Learning Technique to Prognosis Diabetes Disease: Random Forest Classifier Approach	84	Springer Nature
IEEE Access	54,351	490,387	9.0	A Metaverse: Taxonomy, Components, Applications, and Open Challenges	508	IEEE
Proceedings - Frontiers in Education Conference, FIE	2,046	2,344	1.1	Designing and implementing an AI education program for learners with diverse background at scale	5	the Institute of Electrical and Electronics Engineers Inc.
Wireless Communications and Mobile Computing	4,310	9,730	2.3	Wireless Communication Technologies for IoT in 5G: Vision, Applications, and Challenges	63	Hindawi

TP=Total Publication, TC= Total Citation, Cite Score= for the Journal

According to Table 2, the most productive journal on AI integration in education was "IEEE Access" with a citation rate of 9.0, followed by "Sustainability" with a citation rate of 5.8.

According to the most productive journal in terms of total publications (TP), "Lecture Notes in Computer Science" has the largest number of publications with 79,131 publications in the subject area. The journal "Proceedings - Frontiers in Education Conference, FIE" has the lowest number of publications with only 2,046.

In terms of total citations (TC), the journal IEEE Access was in first place with 490,387, while the journal "Proceedings - Frontiers in Education Conference, FIE" had the fewest citations with 2,344. Journals with a high number of citations, a high number of publications and notable publications have strongly influenced the development of research on the integration of AI in education.

The most Significant Countries

To investigate the third question of the study: Which countries have had the greatest impact on the integration of artificial intelligence in educational research? An examination of the data provided reveals a diverse global influence, as shown in Figure 3. Distribution of publications by country.

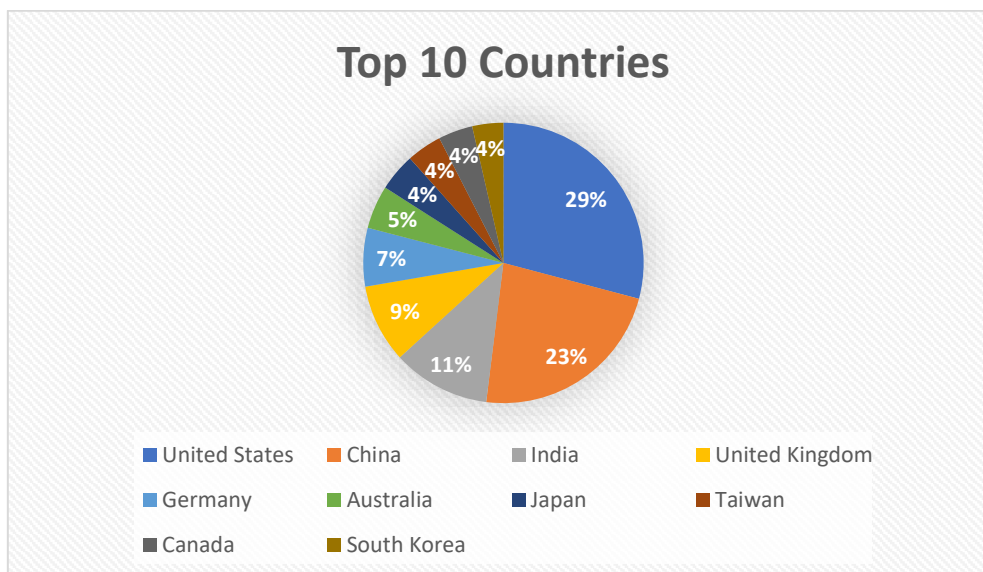


Figure 3. Publications distributions by countries

Figure 3 shows the most significant distribution of publications, with the United States leading the top ten nations in terms of publication volume with 682 articles, accounting for 29% of all publications in this research area. China is in second place with 535 articles, accounting for 23% of all publications. The distribution of articles published in this research area is 11% (264), 9% (212), 7% (158) and 5% (117) for India, the United Kingdom, Germany and Australia respectively. At the bottom of the list, four countries are tied with 4% of published articles each: Japan (102), Taiwan (95), Canada (93) and South Korea (84).

Collectively, these countries account for a significant proportion of global academic research on the integration of artificial intelligence in education. This emphasises the broad and diverse interest that exists across continents. The wide range of contributions illustrates the global importance of e-learning platforms in today's education systems and the international endeavour to understand their impact on education and learning.

The most significant educational institutions

The data provided in response to the fourth research question, "Which educational institutions have made the most notable contributions to the study of AI integration in education?", highlights a number of educational institutions, as shown in Figure 5, Table 3 and Figure 4.

Table 3

The most significant educational institutions in AI integration in education research within the last 7 years

Educational institution	TP	Country
University of Science and Technology	32	United States
Carnegie Mellon University	28	United States
University College London	27	United Kingdom
Georgia Institute of Technology	22	United States
Monash University	21	Australia
NC State University	19	United States
Stanford University	19	United States
Amity University	19	India
Chinese University of Hong Kong	17	Hong Kong
University of Toronto	17	Canada

TP= Total publication

Table 3 shows the ten most notable educational institutions that have contributed to this research area "AI integration in education". The United States is the leading country in this research area, as 5 of the top ten educational institutions are based in the United States. These institutions are the University of Science and Technology, Carnegie Mellon University, Georgia Institute of Technology, NC State University and Stanford University. The total number of publications (TP) was as follows: 23, 28, 22, 19, and 19. The United Kingdom followed in second place with one major institution, "University College London, with 27 total publications, and finally, Hong Kong and Canada had the fewest total publications on this research topic, with 17 from the Chinese University of Hong Kong and the University of Toronto, respectively. Figure 4 illustrates the international distribution of publications.

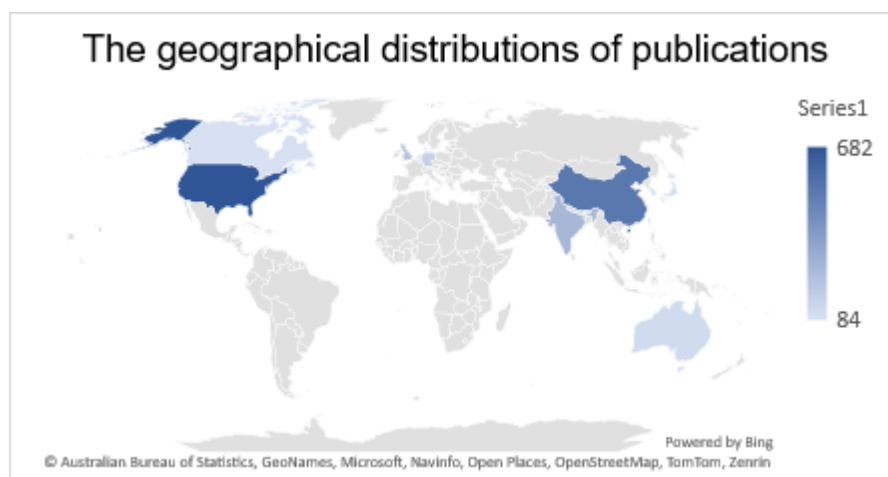


Figure 4: the geographical distributions of publications

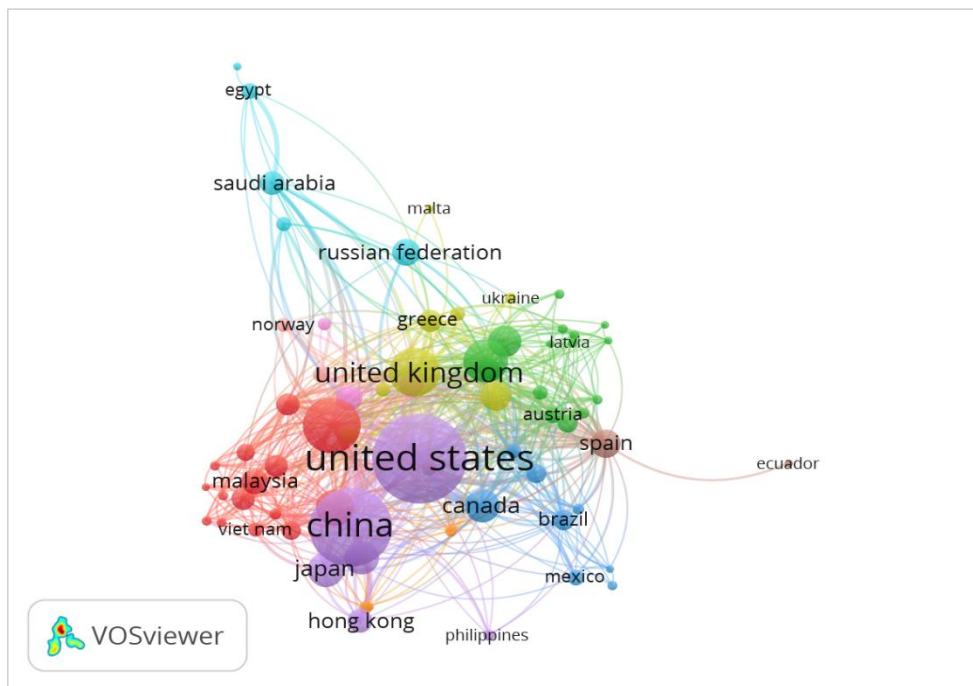


Figure 5: the geographical distribution based on VosViewer software

The international presence of these institutions in various countries emphasises the global reach of research in the field of artificial intelligence (AI). Their remarkable contributions demonstrate the wide diversity of approaches and perspectives used in researching AI platforms and their impact on learning outcomes in education. This diversity not only enriches the field, but also contributes to a broader understanding of how AI platforms influence educational practise across different educational methods and cultural connections.

The most Prolific Authors

Regarding the fifth research question: "Which authors have made the most significant contributions to the field of AI integration in education?" The data in Table 4 highlights several authors who have made significant contributions to this area of study.

Table 4

The top 10 authors in the field of AI integration in education research area

Author	Year of first publication	TP	h-index	TC	Current affiliation	Country
Breazeal, Cynthia L.	1998	290	62	14,451	Massachusetts Institute of Technology	United States
Cukurova, Mutlu	2016	96	18	1,050	University College London	United Kingdom
Chai, Ching Sing	2005	256	50	7,887	Chinese University of Hong Kong	Hong Kong

Chiu, Thomas K.F.	2015	61	22	1,549	Chinese University of Hong Kong	Hong Kong
Glazewski, Krista D.	2004	85	15	1,226	Indiana University Bloomington	United States
Hwang, Gwojen	1995	550	75	21,887	National Taiwan University of Science and Technology	Taiwan
Ito, Takao	2015	17	4	79	Kanazawa Institute of Technology	Japan
Kahn, Ken M.	1994	63	15	1,477	University of Oxford	United Kingdom
Lee, Irene A.	2011	27	11	916	MIT STEP Lab	United States
Lee, Seung Y.	1999	33	8	264	NC State University	United States

TP=Total Publication, TC= Total Citation

The most profound authors are listed in Table 4. Breazeal, Cynthia L., for example, an American scientist and entrepreneur who published her first work in 1998, has a remarkable 290 publications and an h-index of 62, equivalent to 14,451 citations, and is affiliated with the Massachusetts Institute of Technology in the United States. Then comes researcher Cukurova, Mutlu, who started publishing in 2016 and to date has 96 articles with 1,050 citations and an h-index of 18. His affiliation with University University London in the UK illustrates his growing importance in the field of human-AI collaboration and integration in educational research. Since his first publication in 2005, Prof Chai, Ching Sing has authored a total of 256 articles and achieved an h-index of 50. The 7,887 citations he has amassed and his affiliation with the Chinese University of Hong Kong in Hong Kong attest to his enduring and influential reputation in the field. Prof Chiu, Thomas K.F., who is associated with the same Hong Kong university, the Chinese University of Hong Kong, has achieved a significant h-index of 22 with 61 published articles and 1,549 citations since he started in 2015. Glazewski, Krista D., an expert in the field of AI problem-based learning, has published 85 articles, been cited 1,226 times and achieved an h-index of 15 since her start in 2004. Indiana University Bloomington in the United States highlights her growing academic focus and research. Hwang Gwojen began publishing his work in 1995 and has since amassed an impressive 550 publications with an h-index of 75 and 21,793 citations. Hwang is affiliated with the National Taiwan University of Science and Technology in Taiwan. His interest in Digital Game-Based Learning and Artificial Intelligence in Education is noteworthy and worth mentioning. Ito, Takao published his first paper in 2015. He has an h-index of 4, 17 articles and 79 citations. He is affiliated with the Kanazawa Institute of Technology in Japan. The researcher Kahn, Ken M. began his targeted research in 1994 and has written a total of 63 publications in the field of object-oriented programming, which have been cited 1,477 times and have an h-index of 15. His association with Oxford University in the UK shows that he has made a significant contribution to this

field of research. Researcher and scholar Lee, Irene A. has been publishing since 2011, she has 916 citations and an h-index of 11, she has published 27 papers. Her academic research interests include integrating AI methods into STEM education and exploring the concept of AI for reason-based instruction. She is a member of the MIT STEP Lab in the United States. Also from the United States and affiliated with NC State University, researcher Lee, Seung Y. has received 264 citations and an h-index of 8 with 33 publications since his start in 1999.

The impact of the application of newly developed technologies, especially Artificial Intelligence, in various fields and in particular the integration of AI in education to meet the internationally increasing demands of the new generation, which is becoming more and more advanced in terms of logical thinking and technological applications, is an emerging phenomenon that educators, teachers and researchers are continuously concentrate on.

The primary research keywords and trends

In response to the sixth question: "What have been the most important research terms in relation to the integration of AI in education in the last seven years?" The figure shows the most important research terms and the frequency of their occurrence, as can be seen from the data in Figure 6 below.

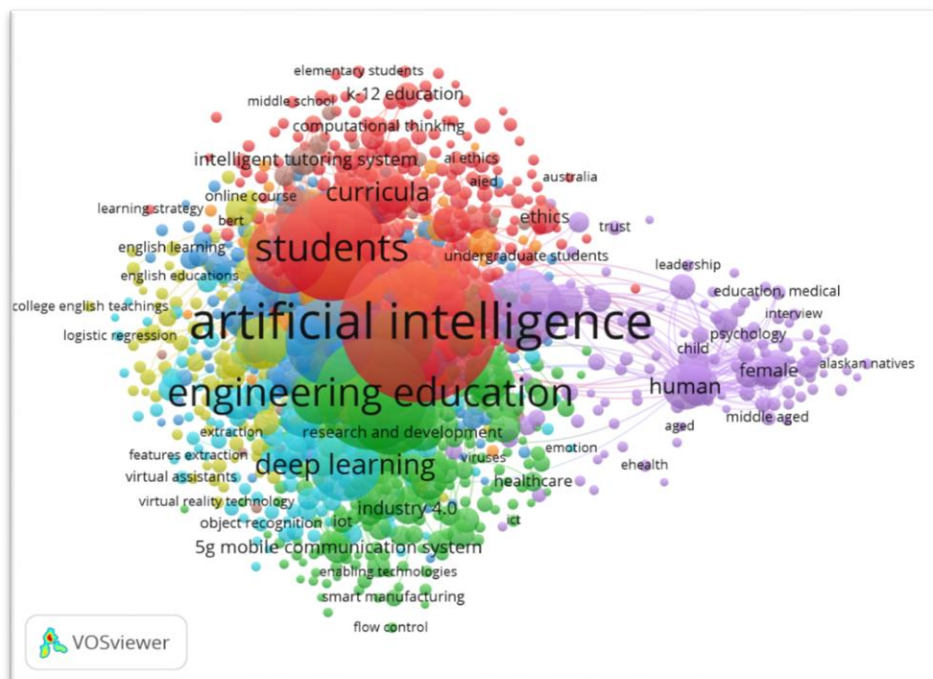


Figure 6: The primary research keywords and their occurrences

Figure 6 illustrates the most important research keywords. Over the past seven years, numerous terminologies have been used for research keywords expressing the integration of AI into education across different platforms, reflecting the wide range of interests in this area of research. The phrase "artificial intelligence" was the most frequently used keyword with 1,455 mentions, indicating its essential importance in educational research. The term "students" was also used frequently, 654 times, emphasising the primary aim of the research. The terms "learning systems" and "machine learning" appeared 442 and 622 times respectively, which also emphasises the importance of using technological applications in education. The terms "educational informatics", "e-learning" and "education" are frequently used to emphasise the conceptual basis of artificial intelligence integration approaches. The

all-encompassing nature of the approach, expressed through the occurrence of "deep learning", 'human', "curricula" and "computer-assisted instruction", as well as 'decision making', suggests that it is a shift in perspective in education towards a more practical approach to decision making. A focussed examination of specific areas such as "artificial intelligence technologies" and "natural language processing systems" means focusing on the methods used to integrate AI into education and how technology is used throughout the process to promote learning through logic and decision making.

The most Important Subject Area

To answer the seventh question of this study: Which topic area is most important for the integration of AI into educational research? Based on the data provided, the most important topic area, with a weighting of 40%, is computer science, which has an extensive collection of 2381 articles. This suggests that technical and technological components of educational e-learning, such as algorithm development, software creation and system architecture, are critical to understanding and improving educational outcomes when using AI platforms, as shown in Figure 7.

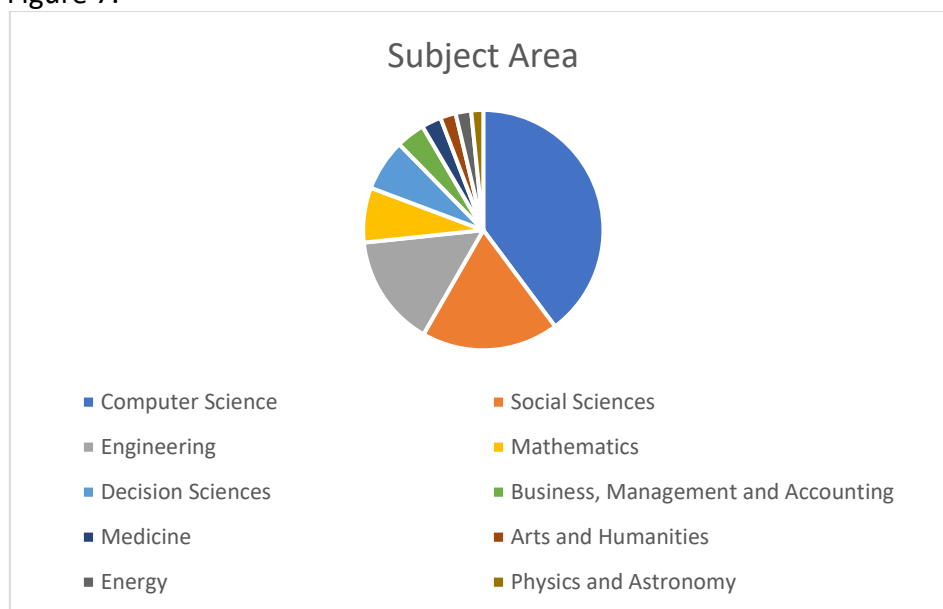


Figure 7: The most important subject area

According to Figure 7, the second area is the social sciences, which account for 18% of articles and have a strong interest in the social, behavioural and pedagogical implications of eLearning, as evidenced by the 1106 articles in close proximity. Engineering, which has 900 articles and accounts for 15% of the sample size, is another important area of interest as it deals with the application of engineering concepts in the development and improvement of e-learning platforms and technologies.

While the presence of the subject areas still makes significant contributions to the discipline with 7% each and a total of 442 and 415 contributions respectively, mathematics and decision sciences make significant contributions to the body of knowledge on the use of AI. Economics, management and accounting follow with 233 publications, showing 4% of interest in management and behavioural aspects of education. In-depth insights into the application of artificial intelligence in education can be reflected by the academic fields of medicine, which takes up 3% with 158 publications.

Respectively, 2% each of arts and humanities, energy, physics and astronomy contribute modestly to the significance of integration in education based on the number of publications on this topic, which amount to 125, 125 and 97 publications respectively.

To summarise, although much research has been conducted in the social sciences and computer science on the integration of artificial intelligence in education via e-learning platforms, several other academic disciplines also contribute to a comprehensive understanding of this multifaceted topic.

The results of this bibliometric study show a variety of scientific works that contribute to our understanding of the relationship between the integration of AI in education and its impact on learning. The growing number of publications, the diversity of contributing countries and institutions, and the dominance of certain topics and keywords indicate that AI in education has a positive impact on education, particularly in terms of learning outcomes. The findings emphasise the multidisciplinary aspect of AI research in education and highlight the combined efforts of academics, technologists and professionals from different countries. This study not only provides useful insights into the current state of knowledge, but also sets the framework for future applications that will have a lasting impact on educational methods and academic experiences.

Discussion

This bibliometric study on the integration of Artificial Intelligence in education and its impact on learning outcomes in education reflects a comprehensive understanding of the new trends related to the integration of technology in education, especially after the increased need in educational institutions at all levels internationally during and after the period of the pandemic, when learners could no longer physically communicate and had to work hand in hand with educational institutions to engage and deliver learning outcomes.

The findings show the development and realisation of the theme of this important study through a variety of contributions from many nations and institutions as well as a growing importance among experts and academic practitioners.

Trends in Publication and Geographic Distribution

The observed increase in academic publications on the relationship between AI and education, particularly after 2019, suggests that this area is receiving increasing attention from academics. The pattern described above demonstrates the importance of understanding the effectiveness of the use of AI in education. It was likely triggered by the global shift to online teaching during the COVID-19 crisis. The significant contributions from countries such as the United States, China, India and the United Kingdom, which are scattered across the world in these publications, emphasise the global reach of the study. The fascinating phenomena of how different educational and cultural contexts have influenced the development of AI integration approaches offer a wealth of perspectives and insights.

Influential Journals and Educational Institutions

The report identifies leading academic publications and institutions that are conducting revolutionary studies on the integration of AI in education. This information is becoming increasingly important for academics as they examine the findings of various research articles in this area. Furthermore, the significance of these academic institutions and publications reflects the newly introduced technology as well as the scientific impact and ability to shape future education and learning techniques.

Prolific Authors and Research Keywords

The continued dedication and achievements of outstanding scholars are honoured by the recognition of prolific authors in the discipline. Their studies form the basis for today's understanding and future advances in the field of artificial intelligence. In addition, the analysis of keywords from primary sources provides useful insights into the diversity and complexity of the field, which encompasses disciplines such as machine learning, engineering education, and technology. Combined with terms such as "students" and "education", which emphasise and promote the human and pedagogical dimensions of learning, the prominence of popular terms such as "educational informatics", "artificial intelligence technologies" and "natural language processing systems" indicates a significant establishment of technological elements.

Subject Areas and Their Implications

The study covers a wide range of topics and emphasises the interdisciplinary nature of machine learning. As the emergence of computer science and the social sciences shows, engineering, educational theory and mathematical decision theory have come together to reflect on the topics under study. The use of an interdisciplinary approach is critical to the development of interesting and effective learning environments that incorporate a variety of technologies and learning methods.

In a nutshell, the results of this bibliometric analysis provide a comprehensive overview of both the current and potential direction of academic research on the integration of artificial intelligence in education and its impact on education and learning outcomes. This growing body of literature is not only critical to academic goals, but also has practical significance for practitioners, educators and technologists. It is of paramount importance for educators to keep abreast of the latest developments in machine learning to ensure that digital learning environments are productive, inclusive and beneficial to educational and learning outcomes.

Summary of the results of this review

The table below provides a consolidated summary of this research article, which provides a comprehensive examination of the development, implications and potential future developments of the integration of artificial intelligence into education, with a focus on its impact on learning outcomes. All information is organised into key categories such as discoveries, impacts, trends and future plans. These categories provide a comprehensive overview of the academic focus, geographical distribution, main authors and subject-specific concentration in education. The aim of the survey is to define the current state of affairs and assess future directions in this rapidly evolving field, as shown in Table 5.

Table 5

A Thorough Examination of Artificial Intelligence integration and Its Influence on Education: Principal Discoveries and Prospects for the Future

Aspect	Findings	Implications	Trends	Future Agenda
Publications	Publications reached peak point in 2022 with 1102 publications reflecting growing interest and need for research.	The scientific publications are related to the growing interest in technology-based solutions for invisible risk situations in education, especially for the pandemic.	The interest in artificial intelligence and augmented reality and their applications started earlier in 2019, creating a need and a trend to be a creative institution with technology-based solutions.	The need for studies and experiments on the quality of AI applications used to facilitate learning and assessment is growing. The education system is undergoing enormous change around the world, giving rise to new learning and teaching methods.
Journals	The most productive journals of AI integration in education are "IEEE access", "Sustainability" and "Lecture Notes in Computer Science".	The journals focus on the latest advances in technological applications used in academia and studied by educators.	A large number of renowned academic journals are excessively following new trends in educational technology.	Further research will highlight and validate the useful methods for educational learning outcomes.
Countries	Most significant distributions are formed in the United States, China, India then the United Kingdom.	The fact that 29% of publications are published in the United States reflects the level of support for scientists and funding from the country's various research organisations.	Competition in technological applications is mainly between the two big gurus, the United States and China. Despite its outstanding contribution in the academic field, the United Kingdom is lagging behind in this race.	Advancement in research into technological solutions for education is a growing global need.

Educational Institutions	“University of Science and Technology” and “Carengie Mellon University” are the top two universities in the field of research.	Five of the top ten educational institutions are based in the United States, accounting for more than 139 of the world's total publications.	Educational institutions are adapting to the latest technological solutions in order to stand out from the crowd and attract the best intellectuals. Nowadays, scholars with a high level of technical knowledge are sought after by these institutions all over the world.	More research by academic institutions is very important to promote the use of all available technology applications, especially AI applications.
Authors	Although authors are from different academic experience and backgrounds, most profound authors are of relatively new in publications and relate to prestigious educational institutions.	The trendy area of learning and its applications, which are popular with learners and professionals in the field of education, is emphasised more strongly.	A higher h-index is closely related to a higher overall citation achieved by writing and publishing in the most topical dilemmas and concerns in various fields such as the area of this research.	Most authors follow the pattern of experiencing and analysing the newly offered and used technological solutions and also comparing them in accordance with different variables related to the educational field.
Keywords	The phrases, Artificial Intelligence, learning systems and Machine Learning. Words like students, e-learning and education.	The focus on e-learning and machine learning shows how important it is to measure the results of education and learning.	The trend towards electronic learning experiences and the use of artificial intelligence in education.	Analysing the quality of the results of machine learning applications and AI integration through specific application experiences.
Subject Areas	Most significant area is Computer Science, Social Science and Education.	Thinking about technological topics helps researchers to understand the	The universal trend among all professionals and education specialists	More emphasis on the subject areas specified by educationalists and experts.

		relevant concepts variables.	key and	relates to computer science and the social sciences.	
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Table 5 summarises the analysis of the relationship between artificial intelligence and its integration into education. The arrangement of the data emphasises the constantly changing nature of the topic. The significant increase in scientific publications and global contributions since 2019 shows the increasing importance and dynamics of the integration of artificial intelligence in education, especially in the years following the outbreak of the COVID-19 epidemic. Educational institutions are using innovative technologies to stand out from the crowd and attract the best minds, and academics with a high level of technological expertise are increasingly sought after by institutions around the world. The participation of many countries, academic institutions and researchers shows how diverse and multidisciplinary this field is. Machine learning is widely recognised as the most up-to-date and accurate alternative area of study and its delivery, as it combines pedagogical concepts, technological breakthroughs and self-study methods. In the near future, a growing number of authors will follow the pattern of testing and investigating the newly offered and deployed technological solutions and comparing these applications on the basis of various features relevant to the field of education. More emphasis will be placed on machine-dependent technologies, global alliances and transdisciplinary research to improve pedagogical efficiency and impact on outcomes in education.

Conclusion

The bibliometric analysis conducted in this study provides a complete and comprehensive examination of the dynamic relationship between artificial intelligence and its integration into current educational practise. It shows that academic research in this area has increased significantly, highlighting the growing importance of machine learning in modern education. The widespread use of certain topics and keywords, as well as the diversity of contributing nations and institutions, illustrates the global and multidisciplinary nature of machine learning research. The worldwide collaboration of academics, technologists and researchers has not only shed light on the current state of research but has also laid the foundation for future studies. This highlights the importance of future analysis of the quality of outcomes from machine learning and AI applications being integrated into unique educational applications. Ongoing research is crucial for influencing educational methods and improving learning experiences in the context of digital platforms and applications.

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