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Artificial Intelligence in Education: A Bibliometric Analysis

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ABSTRACT

Artificial intelligence is a technological field that mimics human cognitive abilities. The rapid development of technology has accelerated the implementation of artificial intelligence in education. The aim of the study is to examine 4935 scientific researches on artificial intelligence in the field of education indexed in the Web of Science (WoS) database between 1981-2024 by bibliometric analysis method. The results of the analysis are given with VOSviewer program. The findings of the study showed that the most studies were conducted in 2023. Most of the studies on this subject are articles and papers. The most frequently published languages are English and Spanish. The results showed that Gwo-Jen Hwang, Melissa Bond and Olaf Zawacki-Richter are the top three most cited authors in the subject area. “Artificial intelligence” and “chatgpt” are frequently used keywords. Hong Kong University of Education and Carnegie Mellon University are the top two institutions with the most published researchers. Springer Nature, IEEE and Taylor & Francis are the top publishing journals respectively. Gwo-Jen Hwang is the most co-cited author. The USA has the highest frequency of cross-country linked publications. It is thought that this research will be a guide for researchers who want to study in the field and will increase their knowledge. The research topic has been analyzed in the WoS database, and it may be recommended to analyze it bibliometrically in other databases such as Scopus.

Eğitimde Yapay Zekâ: Bir Bibliyometrik Analiz

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ÖZET

Yapay zekâ insan bilişsel yeteneklerini taklit eden teknolojik bir alandır. Teknolojinin hızlı gelişmesi, eğitimde yapay zekânın uygulamaya konulmasını hızlandırmıştır. Araştırmanın amacı, 1981-2024 yılları arasında Web of Science (WoS) veri tabanında indekslenen eğitim alanında yapay zekâ konusundaki 4935 bilimsel araştırmayı bibliyometrik analiz yöntemiyle incelemektir. Analiz sonuçları VOSviewer programı ile verilmiştir**.** Araştırmanın bulguları çalışmaların en fazla yapıldığı yılın 2023 olduğunu göstermiştir. Bu konu ile ilgili çalışmaların büyük kısmını makaleler ve bildiriler oluşturmaktadır. En sık yayın yapılan dillerin başında İngilizce ve İspanyolca gelmektedir. Araştırma sonuçları Gwo-Jen Hwang, Melissa Bond ve Olaf Zawacki-Richter yazarlarının konu alanında en çok atıf alan ilk üç yazar olduğunu göstermiştir. "Artificial intelligence" ve "chatGPT" sık kullanılan anahtar kelimelerdir. Hong Kong Eğitim Üniversitesi ve Carnegie Mellon Üniversitesi en çok yayın yapan araştırmacıların bulunduğu ilk iki kurumdur. Springer Nature, IEEE ve Taylor & Francis sırasıyla en çok yayın yapan dergilerdir. En fazla ortak atıf yapılan yazar Gwo-Jen Hwang'dır. ABD en yüksek frekansla ülkeler arası bağlantılı yayın sayısına sahip ülkedir. Bu araştırmanın alanla ilgili çalışma yapmak isteyen araştırmacılara rehber olacağı ve onların bilgi birikimlerini artıracağı düşünülmektedir. Araştırma konusu WoS veri tabanında incelenmiş olup, Scopus gibi diğer veri tabanlarında bibliyometrik açıdan analiz edilmesi önerilebilir.

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INTRODUCTION

According to Minsky, one of the pioneers of artificial intelligence, artificial intelligence (AI) is defined as the fulfillment of tasks that require human intelligence by machines (Jiang et al., 2022). While the origins of artificial intelligence date back to the robot drawings of Al Jazari (1136-1206) (Coşkun & Gülleroğlu, 2021), its foundations are known to date back to the 1940s. One of the pioneering works in this field is thought to be the story Runaround, published by American science fiction writer Isaac Asunov, about a robot developed by engineers Gregory Powell and Mike Donovan (Haenlein & Kaplan, 2019). The concept of "artificial intelligence" was first expressed by John McCarthy in 1956 (Melak et al., 2024). Its modern expression dates back to Alan Turing. Known as the British mathematician and the father of artificial intelligence, Turing developed a code-breaking machine called The Bombe for England in order to solve the Enigma code used by the Germans during World War II. The Bombe was able to break the impossible code and made Turing more curious with its artificial intelligence. Turing published his paper "Computing Machinery and Intelligence" and developed the Turing test, which is used today (Coşkun & Gülleroğlu, 2021; Haenlein & Kaplan, 2019).

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Artificial intelligence covers a wide range of human cognitive abilities such as problem solving, learning, reasoning, language processing. Artificial intelligence is a system based on the effort to simulate and improve human intelligence (Jiang et al., 2022). Research areas of AI include engineering, psychology, cognitive science, mathematics, computer science and many more. Artificial intelligence has application areas such as recognizing and processing given speech, analyzing digital images, pictures, videos, robotic surgery, simulation, health monitoring, health system analysis, diagnosis of neurological conditions, language processing, intelligent robots, autonomous vehicles, energy systems (Gondal, Khalid Masud, 2018). With the widespread use of artificial intelligence in areas such as advertisements, TV series/movies and social media, the concept of artificial intelligence has reached large masses and has become an intriguing topic (Saçan et al., 2022). The increasing integration of man-made machines and robots in our daily lives has increased the number of studies on artificial intelligence (Tellan, 2020).

Considering its increasing capabilities and widespread applications, artificial intelligence is expected to be integrated into almost every aspect of our daily lives in the future (Koçyiğit & Darı, 2023). Artificial intelligence, which has been around since the 1960s, has increased its integration with education with the development of intelligent tutoring systems (Bond et al., 2024).

Artificial Intelligence (AI) has the potential to overcome the challenges in today's education, innovate teaching and learning practices, and accelerate progress towards SDG 4. Artificial intelligence, which can develop different alternatives for an equitable, inclusive, quality education, brings risks and challenges along with rapid technological developments (UNESCO, 2024).

Pratama, Sampelolo & Lura (2023) found that 88% of the students strongly agreed that AI is helpful for learning according to the results of the survey they used in their study. According to the results of the research, artificial intelligence increased engagement with personalized learning

experiences and positively affected learning outcomes (Pratama et al., 2023). In the study conducted by Badi, Khan, and Alotaibi (2022), it was determined that instructors and students in higher education institutions had a positive attitude towards AI-supported personalized learning applications as a result of the analysis of 91 data sets (Al-Badi et al., 2022). Technological developments in education in recent years have been the subject of many studies in education as well as in different disciplines. Today, artificial intelligence applications significantly improve the quality of education in areas such as course content preparation, individual performance monitoring, and instructional model selection (Meço & Coştu, 2022). While the integration of AI into education systems offers significant advantages such as personalized learning, it has also brought challenges such as ethical concerns, privacy concerns, inequality issues and lack of technological literacy (Akyel & Tur, 2024). It is possible to see many studies in which different technologies are used in education.

The bibliometric analysis method, first used by Pritchard (1969), has gained widespread popularity in understanding the literature (Zhang et al., 2019). According to Pritchard, bibliometrics is the analysis of books and other communication tools with mathematical and statistical methods (Pritchard & Wittig, 1981).

The aim of this study is to examine 4935 scientific researches on artificial intelligence in the field of education indexed in the Web of Science (WoS) database between 1981-2024 by bibliometric analysis method and present them to the literature.

Identifying research topics in rapidly developing fields is a complex process for researchers. This research of the field of artificial intelligence in education will provide researchers with a comprehensive framework on the current state of the field, potential research topics and gaps in the literature. The number of artificial intelligence studies in education is increasing in our country and in the world over time. Through this research, researchers will be able to direct their work in a way that contributes to the needs and future development of the field.

Research Topic and Problems

The subject of the research is to analyze international scientific research on artificial intelligence in the field of education. The main problem of the research is to analyze the current status of international scientific publications on artificial intelligence in the field of education in bibliometric indicators. Based on this problem, sub-problems were determined as follows:

Studies on artificial intelligence in the field of education,

Studies on artificial intelligence in the field of education,

1. Growth and Spillover Trends
   a. How have their numbers and citation data statistics been over the years?
   b. What is their distribution according to the types of publications?
   c. What is their distribution according to the languages in which they were prepared?
   d. What are the journals that publish the most studies?

2. Content and Thematic Analysis
   a. How are the most cited authors and the number of studies?
   b. How is the social network analysis and usage intensity of common keywords?
   (What are the most frequently used keywords?)

c. What is the distribution of authors according to the institutions they work for?

3. Collaboration and Impact Analysis

a. What are the countries and collaborations in co-authorship analysis?

Literature Review

Bibliometric analysis is an effective tool that structures research areas, reveals interdisciplinary connections, identifies important authors and studies that identify gaps and current trends in the literature (Block & Fisch, 2020). The bibliometric analysis method, which has a wide range of applications, offers the opportunity to examine the scientific literature in depth with different analysis techniques and statistical approaches (Kaleci, 2023). Bibliometric studies provide researchers with the opportunity to access the information required before the research in the shortest time possible. Bibliometric studies provide researchers with the opportunity to access the information required before the research in the shortest time possible.

Many studies have been conducted in the literature on artificial intelligence in the field of education. There are studies examining the use of artificial intelligence tools in terms of academic and educational integrity (Bozkurt, 2024). When the related literature was examined, studies revealing the trends of studies on artificial intelligence in the field of educational sciences were observed (Güzey et al., 2023; Akdeniz & Özdinç, 2021; Tekin, 2023; Hwang & Tu, 2021; Zawacki-Richter et al., 2019). When the related literature was examined, studies on how artificial intelligence will contribute to education, how it will improve education, and what are the artificial intelligence applications used and can be used in education were seen (Arslan, 2020; Savaş, 2021; Meço & Coştu, 2022; Tekin, 2023; Aktay, 2022; Akdeniz & Özdinç, 2021; Chiu et al., 2023; Chiu, 2021; Chen et al., 2022; Lee et al., 2022; Chan, 2023; Wu & Yu, 2024). Cooper (2023) conducted a study on the use of artificial intelligence in science education and talked about the use of ChatGPT in education.

According to the research findings, there were concerns about the inadequacy of training on artificial intelligence and plagiarism (Sánchez Vera, 2023). Chaudhry et al. (2022) investigated the transparency requirements of AI in education for different stakeholders such as educators, educational technologists, and AI practitioners.

This study provides a detailed and comprehensive picture for researchers who want to work in the field of artificial intelligence in the field of education. It is thought that this research will guide researchers to identify different and current study topics for the related field. The examination of scientific studies on artificial intelligence in the field of education indexed in the WoS database has scientific necessity and importance in terms of determining the international effectiveness and change trends of the field.

It is thought that investigating international studies on artificial intelligence in the field of education with bibliometric analysis method will guide researchers who want to work on this subject and increase the knowledge of researchers.

Theoretical Framework

Artificial Intelligence

As a result of many years of efforts, artificial intelligence has become available in every field and has offered the opportunity to turn humanity's dreams into reality. Artificial intelligence adapts human characteristics such as decision-making, learning and generalization by using computers and software (Elmas, 2021). Robots that can recognize faces (SONY SDR-4X), driverless cars (Toyota Ruis, the first car on the road), robots with human emotions (robot developed by Professor Fumio Hara at the University of Tokyo), Infravoice System that makes life easier for the visually impaired (thanks to the headset developed at the Royal National Institute in the UK), unmanned aerial vehicles (UAV-drones), robots that can imitate human limbs (Meltant-a Avatar Robot that can imitate the human hand), quantum computers (computers that can solve complex, unsolvable problems in seconds) are some of these areas of use (Nabiyev, 2021). The rate of technological progress has far surpassed predicting the areas of use of artificial intelligence.

Artificial Intelligence in Education

Artificial intelligence, which was previously the subject of science fiction movies, is now integrated into many fields. Artificial intelligence has brought and continues to bring revolutionary innovations in areas such as discovery, learning and communication (Goralski & Tan, 2020). Artificial intelligence offers many advantages such as improving the quality of learning in students, creating student-centered learning paths, and providing students with timely feedback on their learning (Ouyang et al., 2023). In the context of education, artificial intelligence offers teachers opportunities such as preparing course content, facilitating performance and written assessments.

Artificial intelligence such as chatbots and virtual tutors tools increase the effectiveness of cognitive learning mechanisms, enabling students to personalize learning processes. Thanks to these tools, students' knowledge acquisition, problem solving and comprehension skills are analyzed in real time learning difficulties are identified (Elshansky, 2021). In line with the data obtained, alternative learning that will enable students to achieve their learning goals environments are created and learning strategies are developed. As a natural consequence of these developments, artificial intelligence in education has become a rapidly growing and developing research area.

METHOD

In this study on artificial intelligence in the field of education, a descriptive research model based on the quantitative research design approach was applied. Descriptive research describes the current characteristics of an event, phenomenon or situation (Büyüköztürk et al., 2018). Bibliometric analysis method and scientific field mapping method were applied in the study. In the study, bibliometric analysis of scientific publications was carried out by searching the keywords “Artificial Intelligent” or “AI” based on “subject” in the WoS database.

The bibliometric analysis method provides the types of documents on the subject, the sources that contribute most to the subject, the most used keywords related to the subject, the most cited authors, and more (Harnal et al., 2024).

Research Design

In this research on artificial intelligence in the field of education, descriptive research model based on quantitative research design approach, bibliometric analysis method and scientific field mapping technique were used.

Data Collection Tools

Web of Science (WoS) is one of the most frequently used databases in the world and researchers from more and more countries are involved in the use of this database in academic articles (Zhu & Liu, 2020). In this study, Web of Science (WoS) database was preferred as a data source. WoS contains different types of documents such as full-text articles, proceedings, reviews, book chapters. WoS is an important data collection tool that provides a comprehensive coverage of scientific studies. VOSviewer program was used to create and visualize bibliometric maps. The detailed and practical interpretation of the graphical representation of large bibliometric maps and the fact that it is free of charge have made the VOSviewer program preferable (Van Eck & Waltman, 2010). The studies to be included in the bibliometric analysis were added to the Zotero source data management application. The difficulties in finding, editing and citing sources in academic studies have made it appropriate to use the free Zotero application, which provides practicality in these areas (Idri, 2016).

Data Collection Process

In the data collection phase, in May 2024, using the keywords "Artificial Intelligence" or "AI" in the WoS database, "subject" was selected as the search criteria, "Education Educational Research" and "Education Scientific Disciplines" were selected in the Web of Science categories, and "Article", "Proceeding Paper", "Review Article", "Early Access", "Book Chapters" and "Book" were selected in the document type, and 4935 academic studies on the subject were examined by bibliometric analysis method according to the search results. VOSviewer program was used to create and visualize bibliometric maps. While obtaining search data, the time interval was preferred as "all time interval". After selecting the filtering criteria, the studies to be included in the bibliometric analysis were added to the Zotero source data management application.

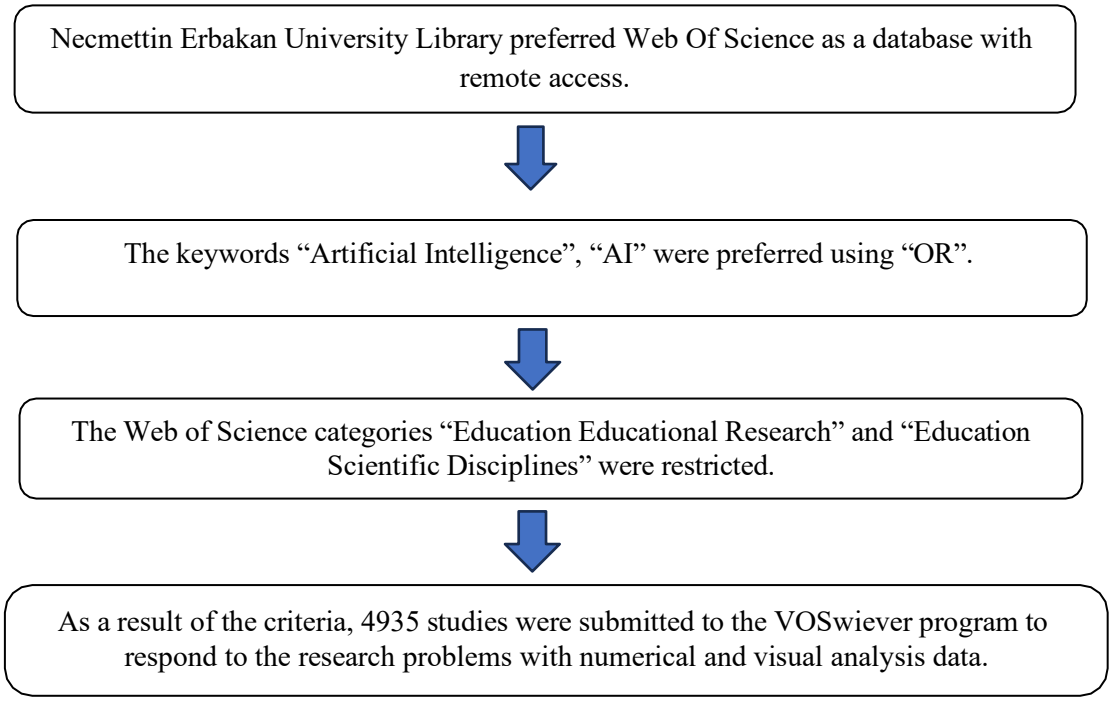

Figure 1. *Working Schematic*

Data Analysis

The data of this study were analyzed bibliometrically. Bibliometric analysis is a rigorous method used to map data results (Donthu et al., 2021). This method has become an indispensable part of the scientific field with the information it provides (Ellegaard & Wallin, 2015). VOSviewer, a free computer program developed for the creation and visualization of bibliometric maps, has an important position in the graphical representation of bibliometric studies (Van Eck & Waltman, 2010). The data of this study were visualized with bibliometric maps using VOSviewer, a bibliometric analysis software. The data obtained were presented as tables and graphs through Word program.

Validity and Reliability of the Study

Validity and reliability are the two most important criteria that determine the value of research. Validity in a quantitative research is closely related to the degree to which the collected data reflect the reality (Yıldırım & Şimşek, 2021). The VOSviewer program used for the analysis of the numerical data obtained, the bibliometric analysis method used in the research, the Web Of Science database that provides the data set of the research are important for the reliability and validity of the study. In this study, the validity and reliability of the research were kept at a high level, based on the opinions of the most frequently cited authors in the field and reliable sources published by internationally recognized institutions. In order to ensure the validity of the research, how the data were obtained, the details of the inclusion and exclusion criteria applied before the formation of the maps, and the steps of the process were given in a clear and understandable manner. Thus, validity and reliability were increased. In order to ensure the reliability of the research, the findings were presented without the author's interpretation and the consistency between the data was taken into consideration. In the conclusion and discussion section, the findings obtained in the study were supported by the literature. Since there was no human participation in this study, ethics committee approval was not required.

FINDINGS

Data on research on artificial intelligence in education are presented in tables and figures.

Statistics for the Research Study

The findings of the research study are given under headings.

Findings on the Number of Studies and Citation Data Statistics by Years

Citation analysis statistics for the outcome data related to the research topic are presented in Figure 2.

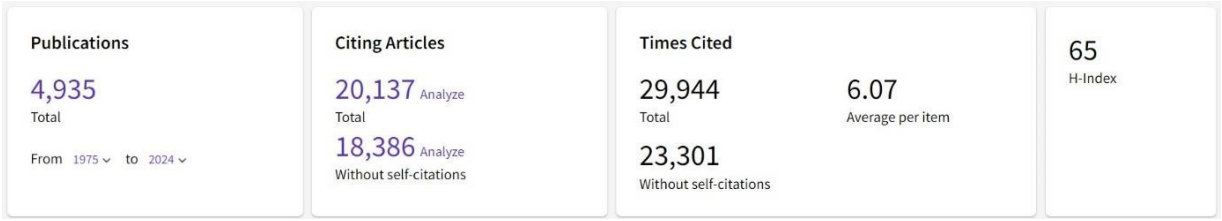

Figure 2. *Citation Analysis of Studies on Artificial Intelligence in Education (WoS May, 2024).*

As seen in "Figure 2", it was determined that there were 29944 citations belonging to 4935 studies for the year 1981 and after. Each study has an average citation rate of 6.07. The H-index value was found to be 65. As a result of the data obtained from the WoS database, the data ranges of the research studies published by the authors related to the study of artificial intelligence and the change of the studies depending on the citation data over time are given in Figure 3.

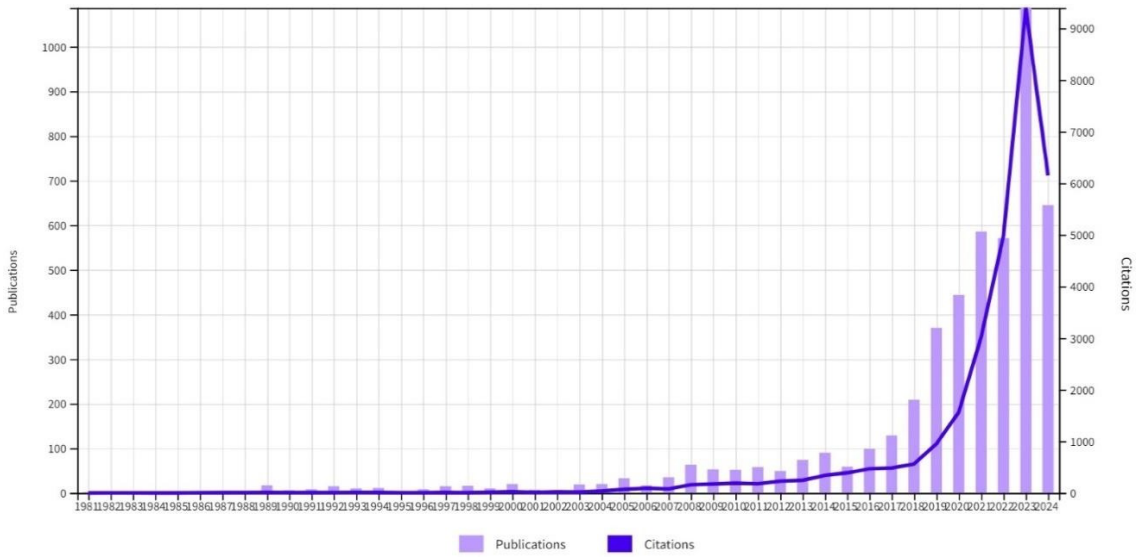

Figure 3. *Research Numbers and Citation Data by Year (1981 and later) (WoS, May, 2024)*

"As can be seen in Figure 3, there has been an increase in the number of studies on artificial intelligence from 2007 onwards, and this increase has not been due to a constant acceleration. Until 2023, it was determined that there was an increase in the number of citations to studies. It was determined that the first research on this subject was conducted in 1981 and the most intensive studies were conducted in 2023 with 1087 studies.

Findings on Frequency Distribution According to Publication Types

The density distribution of studies published in WoS on artificial intelligence in education according to publication types is shown in Figure 4.

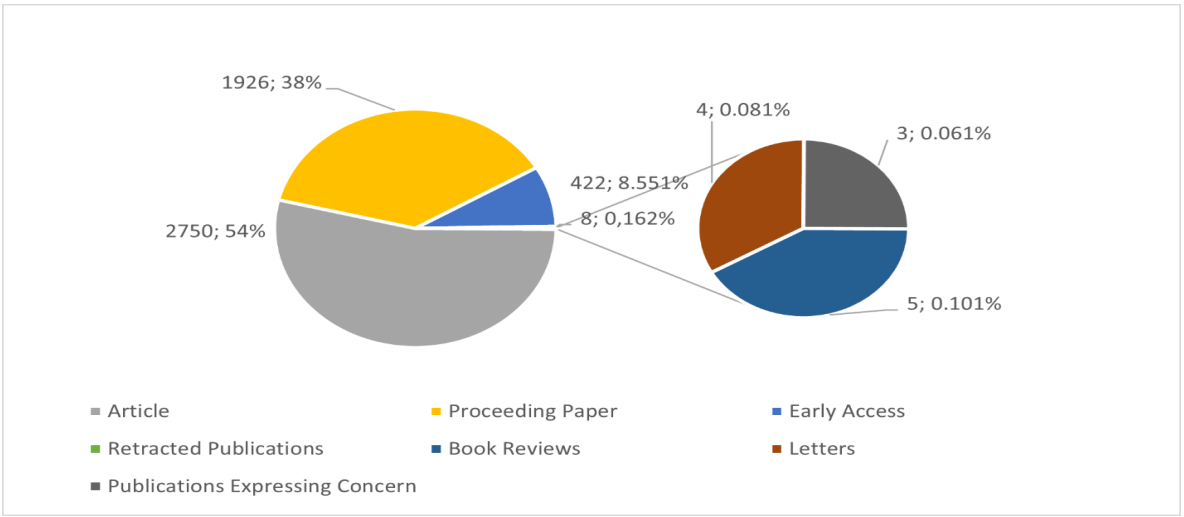

Figure 4. *Distribution of Data on Artificial Intelligence by Publication Types (WoS, May, 2024)*

"As can be seen in Figure 4, the majority of academic studies published on artificial intelligence are articles (f= 2750, 55.724%), followed by papers (f=1926, 39.027%), early access (f=422, 8.551%), retracted publications (f=8, 0.162%), book reviews (f=5,0.101), letters (f=4, 0.081) and publications expressing concern (f=3, 0.061). The types of publications with lower percentages in the pie chart are visualized more clearly with an additional pie chart to the right of the pie chart for a clearer understanding of the chart. The first number indicates the frequency of the publication types and the second number indicates the percentage of these types in the research.

Findings on the Distribution According to the Languages of Preparation

The distribution of the languages in which the studies on artificial intelligence in education were published in WoS is shown in Table 1.

Table 1. *Distribution of Academic Studies on Artificial Intelligence by Languages Tablo 1.*

No	Languages	Frequency	Percentage (%)
1	English	4768	96.616
2	Spanish	93	1.884
3	Portuguese	17	0.344
4	Russian	17	0.344
5	Chinese	13	0.263
6	French	4	0.081
7	Turkish	4	0.081

"As can be seen in Table 1, the languages with the most intensive use in relation to this topic are English (f=4768, 96.616%), Spanish (f=99, 1.884%), Portuguese (f=17, 0.344%), Russian (f=17, 0.344%), Chinese (f=13, 0.263%), French (f=4, 0.081%) and Turkish (f=4, 0.081%).

Findings on the Most Cited Authors and Number of Studies

In order to obtain information about the number of citations and studies of the authors on this subject, the criteria of at least 2 studies produced by an author and at least 20 citations to the studies produced by the author were applied and the visual of the data obtained by applying the criteria is shown in Figure 5 through VOSviewer. The high number of citations of a single study may be coincidental or may be related to the popularity of the topic in the year of the study. Since the evaluation of a single study may not accurately represent the overall impact of the author, the number of studies was set to at least 2. The number of citations of the author was chosen to be at least 20 to ensure that the map is both comprehensive to include important authors and free from the complexity that may arise due to frequent data. The selection criteria were evaluated in each case and varied.

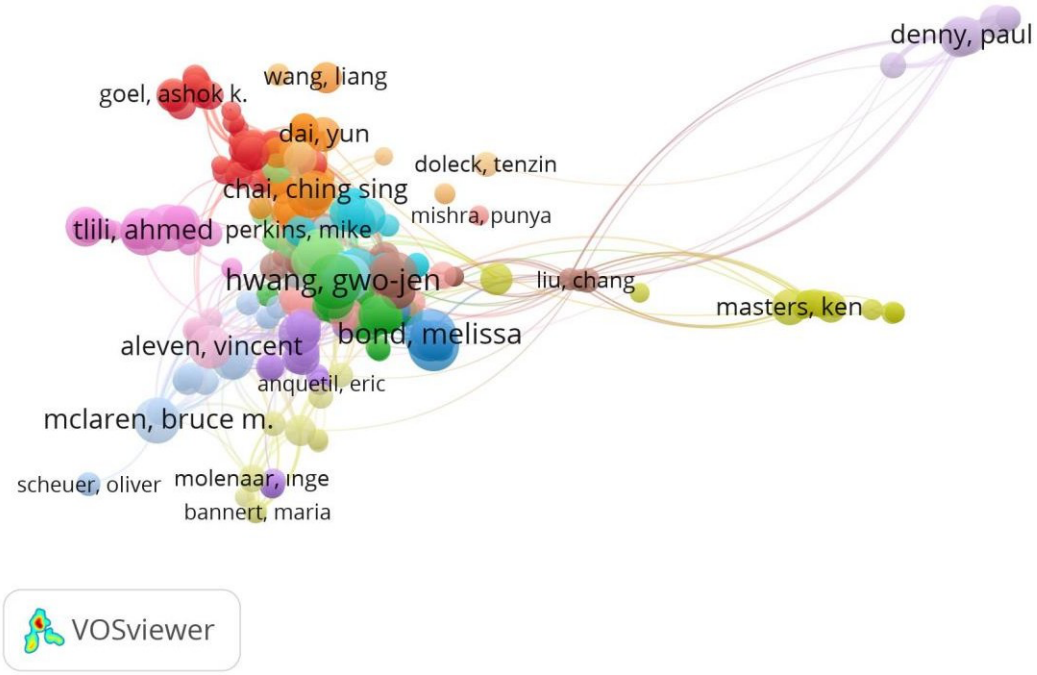

Figure 5. *Author Citation Network Map Visualization (VOSwiever, May ,2024)*

As seen in "Figure 5", the most cited authors in the field of artificial intelligence in the field of education are presented with a network map. 438 out of 13267 authors met the threshold value determined in the program by conducting a minimum of 2 studies on artificial intelligence and receiving at least 20 citations. 19 clusters, 357 items and 2522 links were identified. The data of these authors are given in Table 2.

Table 2. *Authors with the Most Cited Data and Number of Studies (VOSwiever, May, 2024)*

No	Author	Number of Studies	Number of Citations
1	Gwo-Jen Hwang	24	605
2	Melissa Bond	2	506
3	Olaf Zawacki-Richter	2	500
4	HXie aoran	15	394
5	Ahmed Tlili	9	373
6	Ronghuai Huang	7	370
7	Aras Bozkurt	7	358
8	Boulus Shehata	2	341
9	Bruce M. Mclaren	10	338
10	Thomas K.F. Chiu	17	321

"As seen in Table 2, the 10 most cited authors are Gwo-Jen Hwang (605), Melissa Bond (506), Olaf Zawacki-Richter (500), Haoran Xie (394), Ahmed Tlili (373), Ronghuai Huang (370), Aras Bozkurt (358), Boulus Shehata (341), Bruce M. Mclaren (338) and Thomas K.F. Chiu (321).

Accordingly, Gwo-Jen Hwang, the most cited author, is in a central position with his works and has influenced other authors. Melissa Bond and Olaf Zawacki-Richter are among the authors with the highest number of citations (506 and 500) despite having 2 studies.

Findings on Social Network Analysis and Usage Intensity of Commonly Used Keywords

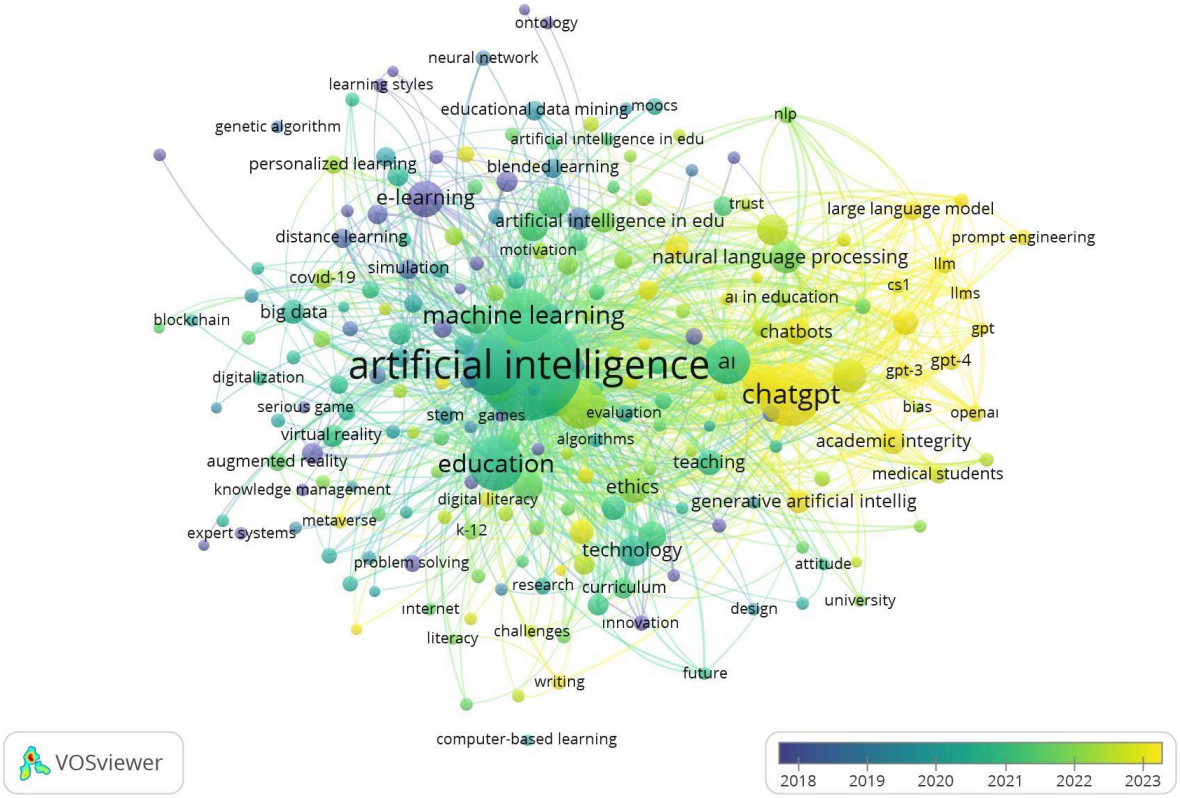

Figure 6. *Common Word Analysis Layer (Visualization) Map Image in the Context of Author Keywords (VOSwiever, May, 2024)*

In the co-occurrence analysis of keywords in Artificial Intelligence themed studies, the minimum number of repetitions was set as 10 and the results of the search are given in Figure 6. With this restriction, 219 out of 10248 keywords met the threshold value.

The areas of research on artificial intelligence and the social interaction network between these areas are shown in Figure 6. In this map, large circles represent the most used keywords and colors representpast and current (most popular) keywords. When the keyword network graph of the studies on artificial intelligence was analyzed, it was found that the keywords were grouped under 8 clusters and 218 topics.

The 10 keywords with the highest frequencies and relevance among the keywords in these subject groups are presented in Table 3.

Table 3. *Table of Frequency and Connection Strength of Commonly Used Keywords (VOSwiever, May, 2024*

No	Keyword	Frequency	Connection Strength
1	Artificial intelligence	1267	2323
2	Chatgpt	388	1037
3	Education	278	720
4	Machine learning	267	605
5	Higher Education	218	477
6	AI	182	541
7	Generative AI	116	349
8	Medical Education	100	346
9	Natural Language processing	91	290
10	Learning analytics	89	169

As seen in "Table 3", the most used keywords related to this topic is artificial intelligence (f=1267, cs=2323), followed by chatgpt (f=388, cs=1037) which is popular today, education (f=278, cs=720), machine learning (f=267, cs=605), AI (f=182, cs=541), Higher Education (f=218, cs=477), Generative AI (f=116, cs=349), Medical Education (f=100, cs=346), Natural Language Proces (f=91, cs=290), Learning Analytics (f=89, cs=169).

In bibliometric analysis studies, density visualizations are given with two types of mapping. These are "item density" maps and "cluster density" maps (Öztürk & Gürler, 2022). Figure 7 shows the item density map visual for keywords.

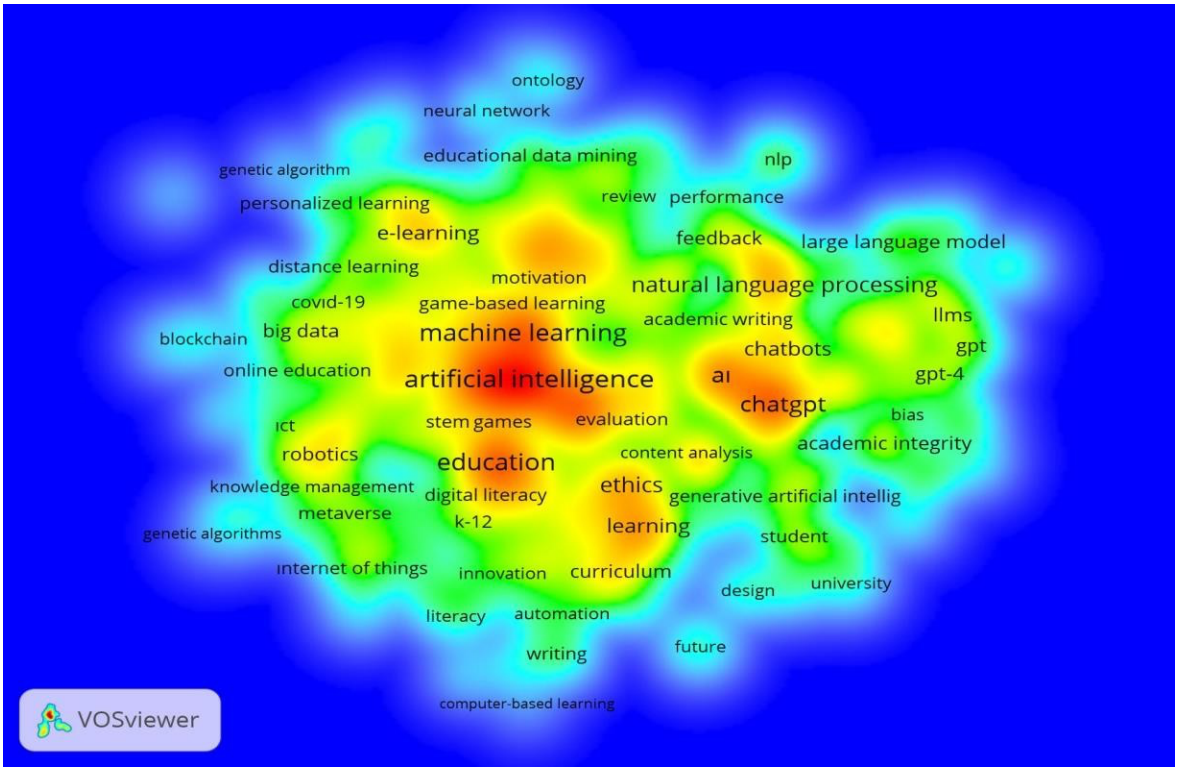

Figure 7. *Visualization of the Keywords' Item Density Map (VOSwiever, May, 2024)*

The colors in the item density maps indicate the number of studies on a particular topic. "As seen in Figure 7, artificial intelligence, ChatGPT, education, machine learning and AI are among the most intensively studied sub-topics.

Findings Regarding the Distribution of Authors According to the Institutions Where They Work

In order to look at the distribution of research on artificial intelligence according to the institutions where the authors work, the criteria of at least 2 publications in each institution and at least 30 citations to published studies were selected and 349 out of 4178 institutions met the threshold. Since some institutions were not linked to each other, 289 institutions that formed large linkage clusters from the dataset were included in the analysis. The map associated with the screening results is given in Figure 8.

In the research, when the distribution network graph of artificial intelligence researches according to the institutions where the authors work was examined, it was seen that the institutions were grouped under 14 clusters and 289 topics.

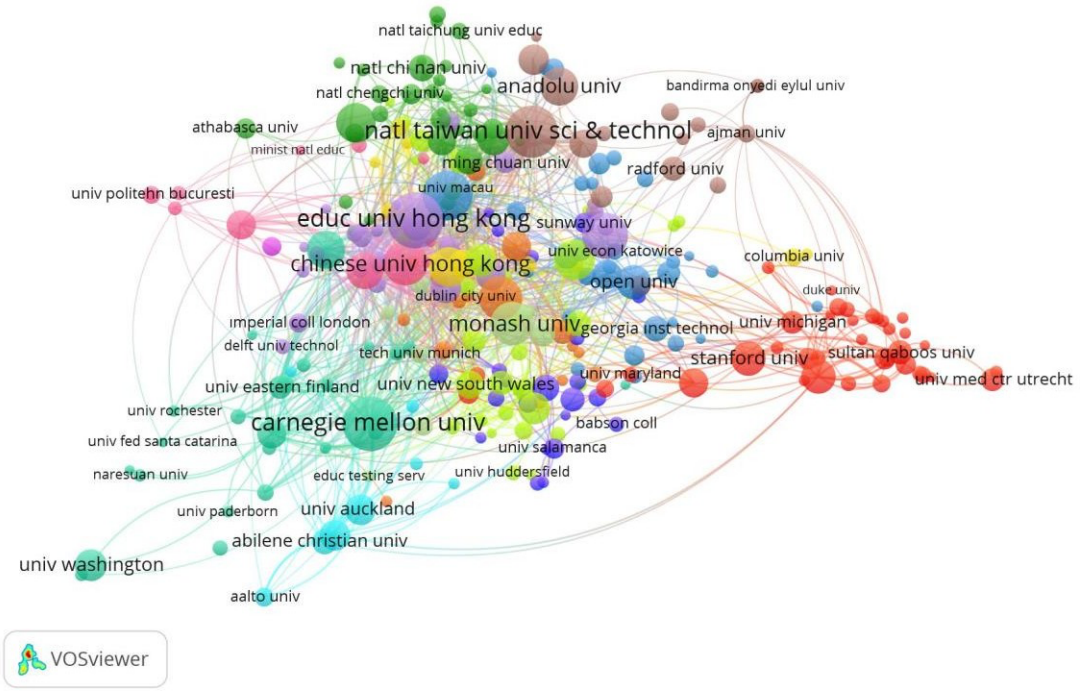

Figure 8. *Network Map Visualization of the Distribution of Research on Artificial Intelligence According to the Institutions where the Authors Work (VOSwiever, May, 2024)*

The data on the number of citations and studies of the institutions in research on artificial intelligence are given in Table 4.

Table 4. *Institutions Where Authors Work in Research on Artificial Intelligence (VOSwiever, May, 2024)*

No	Institutions	Number of studies	Citation Count
1	The Education University of Hong Kong	53	736
2	Carnegie Mellon University	55	705
3	National Taiwan University of Science and Technology	32	644
4	Beijing Normal University	44	600
5	Carl von Ossietzky University of Oldenburg	4	501
6	The Chinese University of Hong Kong	51	487
7	Monash University	47	471
8	University College London	41	458
9	The University of Edinburgh	28	401
10	RWTH Aachen University	7	391

As seen in "Table 4", the top three institutions with authors publishing on artificial intelligence are Hong Kong University of Education (f=736), Carnegie Mellon University (f=705) and National Taiwan University of Science and Technology (f=644).

Findings on the Distribution of Journals Publishing the Most Studies

The journals that published the most scientific studies on the subject are presented in Table 5 according to the results of Web of Science database analysis.

Table 5. *Journals Publishing the Most Research (WoS, May, 2024)*

No	Journal Name	Frequency	Percent (%)
1	Springer Nature	757	15.318
2	IEEE	463	9.369
3	Taylor & Francis	431	8.721
4	Assoc Computing Machinery	254	5.140
5	Wiley	232	4.694
6	Assoc Advancement Artificial Intelligence	197	3.986
7	Elsevier	188	3.804
8	Iated-Int Assoc Technology Education & Development	171	3.460
9	Sage	146	2.954
10	Emerald Group Publishing	89	1.801

"As seen in Table 5, Springer Nature (f=757, 15.318 %), IEEE (f=463, 9.369 %), Taylor & Francis (f=431, 8.721 %) are the top three journals with the highest number of research publications on this subject respectively.

Findings on Authors' Co-Citation Analysis in the Context of Cited Authors

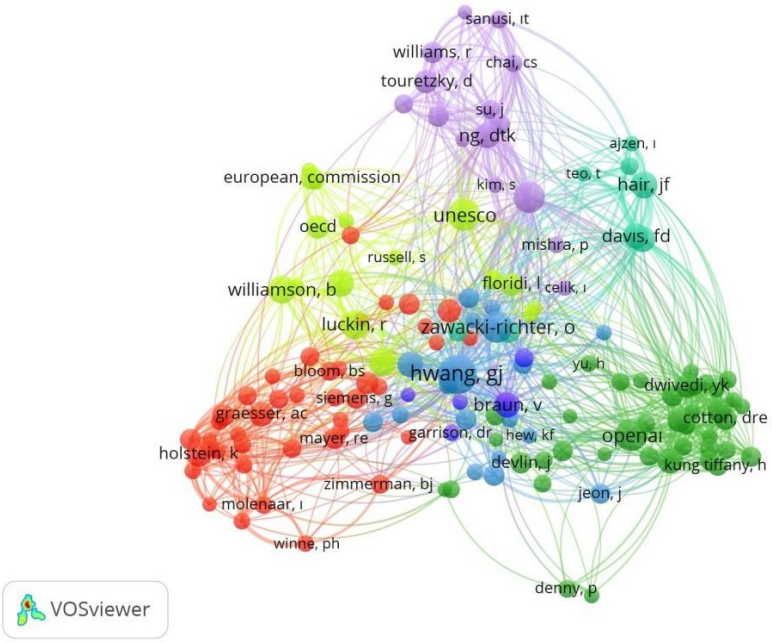

Figure 9. *Authors' Co-Citation Analysis Network Map Visualization (Voswiever, May, 2024)*

In the study, "co-citation" was selected as the type of analysis, "cited authors" was selected as the unit of analysis, the minimum number of documents was set at 50, and 146 authors met the threshold value. The co-citation analysis map of the authors with citation data is presented in Figure 9 through the VOSwiever program.

According to the network map of the co-citation analysis of the studies in the context of the cited authors, it was seen that the institutions were grouped under 7 clusters and 146 topics.

Table 6. *Co-Citation Analysis Table in the Context of Cited Authors (Voswiever, May, 2024)*

No	Authors	Common Citation Count	Total Link Strength
1	Gwo-Jen Hwang	356	2688
2	Unesco	241	1410
3	Openaı	239	1422
4	Thomas K.F. Chiu	228	2167
5	Olaf Zawacki- Richter	219	1821
6	Rose Luckin	199	1374
7	Ben Williamson	180	950
8	Wayne Holmes	171	1694
9	Neil Selwyn	161	1043
10	Joseph F. Hair	159	1536

"As seen in Table 6", the author with the highest number of co-citations is Gwo-Jen Hwang (356).

Findings on Countries and Collaborations in Coauthorship Analysis

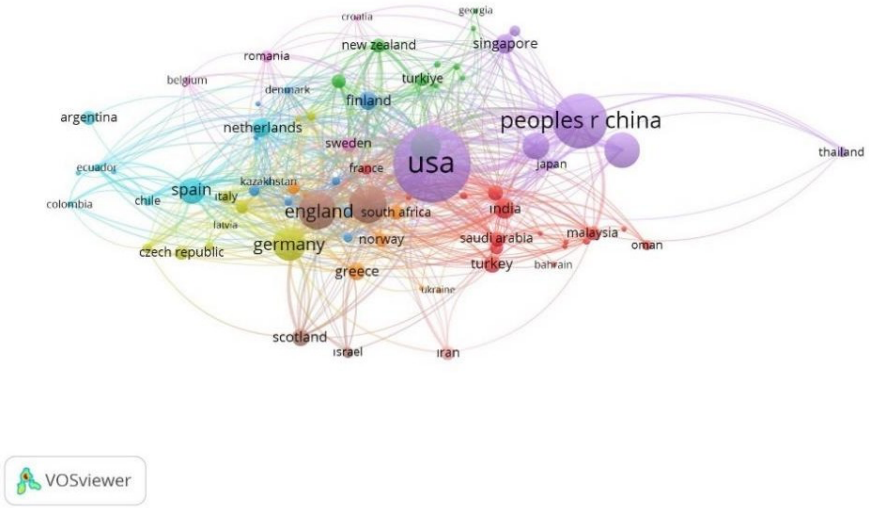

Figure 10. *Network Map of Countries and Collaborations in Co-Authorship Analysis of Studies Related to Artificial Intelligence (Voswiever, May, 2024)*

In the co-authorship analysis of studies on artificial intelligence, in order to look at the cross-country collaboration of publications, a search was made with the condition that each country should have a minimum of 4 studies and a minimum of 4 citations, and it was seen that 83 out of 121 countries met the specified threshold values. Of these countries, 79 countries with high connections were included in the data analysis and the analysis map is given in Figure 10 through the VOSwiever program.

In the co-authorship analysis of the studies, when the network graph presenting the cross-country collaborations of the publications was examined, it was seen that the institutions were grouped under 10 clusters and 79 topics.

Table 7. *Top 10 Countries in Co-authorship Analysis of Publications and Collaborations*

No	Countries	Number of Studies	Number of Citation
1	United States of America	1131	8557
2	Chine	672	4432
3	England	320	2270
4	Australia	257	2163
5	Taiwan	196	1999
6	Germany	219	1816
7	Canada	198	1431
8	South Korea	109	1209

9	Spain	249	1103
10	India	133	730

"As seen in Table 7, the USA has the highest number of cross-country linked publications with the highest frequency (number of studies=1131, number of citations=8557). The top 5 countries following the USA are People's Republic of China (number of studies=672, number of citations=4432), England (number of studies=320, number of citations=2270), Australia (number of studies=257, number of citations=2163), Taiwan (number of studies=196, number of citations=1999), Germany (number of studies=219, number of citations=1816).

China is at the forefront of artificial intelligence in education. China's desire for global leadership in this field, formalizing existing investments and increasing budget investments in this field with the presentation of the National Artificial Intelligence Strategy to the public in 2017, paved the way for it to become a global pioneer in the field of artificial intelligence (Şahin, 2023).

CONCLUSION and DISCUSSION

Within the scope of this study, firstly, a detailed literature review was conducted and bibliometric analysis studies on artificial intelligence in the field of education were examined. WoS database was used for the literature review and inclusion and exclusion criteria were determined. The studies considered to be included in the study were added to the Zotero bibliography management system. In the study, 4935 academic studies conducted between 1981 and 2024 were analyzed. In the study, the number of studies and citation statistics by years on the subject of artificial intelligence in education, the distribution of the number of publications according to publication types, the writing languages of the studies, the most cited authors and the number of studies, keyword analysis and usage intensity, the distribution of studies on artificial intelligence according to the institutions where the authors work, the journals with the most academic publications, countries and collaborations in co-authorship analysis were examined under the headings, and the data obtained from the analysis were presented. According to the results of the research:

It was observed that there was an increase in the studies on artificial intelligence in education in 2007 and after and that this increase was not due to a constant acceleration. The year with the highest number of studies was determined as 2023 with 1087 studies. It is thought that the reason for the decrease in the number of studies in 2024 may be related to the fact that the study was conducted in May 2024. The 2024 research findings showed that the H-index value was 65 and there were 6.07 citations per study.

The first academic study on artificial intelligence in education was John P. Gallagher's article in 1981. Gallagher (1981) experimentally evaluated two design features of an artificial intelligence system used to improve problem solving skills.

Most of the academic studies published on this subject are articles (55.724%, f=2750) and papers (39.027%, f=1926).

Articles are considered the most valuable type of academic publication because they are evaluated by impartial referees in periodicals. Unlike other types of publications, articles place more emphasis on discussion and conclusions. Papers, which are used to present the results of studies, are especially practical for novice researchers, and more qualified works can emerge thanks to the

exchange of information during the presentation through papers (Dinçer, 2021). These situations may have revealed the ratio results in the research findings.

According to the results of the research, the most studied language is English (f=4768, 96.616%). English is followed by Spanish (f=93, 1.884%) with a much lower rate. The widespread use of English as a language of science and the fact that most of the journals in comprehensive database platforms such as Web of Science (WoS) have adopted English as the language of publication may be considered as the reason why English language is preferred more than other languages in publications.

The 6 most cited authors are Gwo-Jen Hwang (605), Melissa Bond (506), Olaf Zawacki-Richter (500), Haoran Xie (394), Ahmed Tlili (373) and Ronghuai Huang (370). Gwo-Jen Hwang's work is central and has influenced other authors. Melissa Bond and Olaf Zawacki-Richter are among the authors with the highest number of citations (506 and 500) despite having 2 studies. Despite having a limited number of studies, their high number of citations indicates that their work has had a significant impact in this field. The most co-cited author is Gwo-Jen Hwang (356).

Hwang & Tu (2021) investigated the role of artificial intelligence in mathematics education with bibliometric mapping analysis. In addition, Lee et al. (2022) applied an artificial intelligence-based chatbot to students and showed that artificial intelligence-based chatbots positively affected students' motivation, academic performance, and learning attitude. Chiu et al. (2023) investigated how to integrate artificial intelligence into the learning, teaching, assessment and management parts of education. In another study, Chiu (2021) developed a curriculum design model for the applicability of artificial intelligence in K-12 schools. Zawacki-Richter et al. (2019) systematically reviewed the research on AI applications in higher education. They found that the articles were mostly written in Computer Science and STEM disciplines. In another study, Zawacki-Richter et al. (2024) investigated various effects of artificial intelligence in higher education.

Common-word analysis identifies research topics and themes in a field (Öztürk & Gürler, 2022). Layer visualization can identify the most popular common words by analyzing changes over time and can offer researchers practicality in identifying research topics in a field. It was determined that the most used keywords related to the subject were “artificial intelligence” (f=1267, bg=2323) and “ChatGPT” (f=388, bg=1037), which is one of today's popular applications.

ChatGPT is an artificial intelligence tool with high accessibility potential that students are increasingly using (Cotton et al., 2023). ChatGPT facilitates learning and teaching with its self-improvement capability and personalized and acceptable responses (Farrokhnia et al., 2024). ChatGPT can create practice questions for students on a specific topic and help them get feedback on the topic (Lodge et al., 2023). All these advantages have made the ChatGPT artificial intelligence tool one of the most studied topics in the research field. The USA is the most active country in the field of ChatGPT, but other countries such as China, Australia and Italy have also conducted significant research in the field of ChatGPT (Duran & Aydın, 2024).

The top five institutions where the authors worked or were supported were Hong Kong University of Education (f=736), Carnegie Mellon University (f=705), National Taiwan University of Science and Technology (f=644), Beijing Normal University (f=600), Oldenburg Carl Von Ossietszky University (f=501). When we examine the 10 universities that attract the most attention in artificial intelligence in education, we see 5 universities from the European region, 4 universities from the

Asian region and 1 university from the American region.

The 10 journals that published the most studies on the subject are given in the table. Springer Nature (f=757, 15.318 %), IEEE (f=463, 9.369 %), Taylor & Francis (f=431, 8.721 %) are the first three journals with the highest number of research publications respectively.

It was observed that the USA had the highest number of cross-country linked publications with the highest frequency (number of studies=1131, number of citations=8557). The top 5 countries following the USA are People's Republic of China (number of studies=672, number of citations=4432), England (number of studies=320, number of citations=2270), Australia (number of studies=257, number of citations=2163), Taiwan (number of studies=196, number of citations=1999), Germany (number of studies=219, number of citations=1816).

The efficiency, national security and social benefits of artificial intelligence have paved the way for countries to compete for global leadership in artificial intelligence (McLaughlin, 2021). Although the US is the leader in the field of artificial intelligence, it faces the risk of falling behind in this field with the rapid steps taken by China (Saygılı, 2020). The artificial intelligence policies adopted by China within the framework of its desire for global leadership have further strengthened the country with the adoption of the National Artificial Intelligence Strategy in 2017, making it one of the leading countries on a global scale (Şahin, 2023).

Artificial intelligence technologies offer significant potential for balancing personalized learning and equity in education. Thanks to AI, students have the opportunity to manage their own learning processes, work in collaborative environments and benefit from autonomous assessment mechanisms (Al-Badi et al., 2022). This situation both increases students' motivation and encourages their active participation in learning processes. In traditional education systems, personalized learning is often limited by high costs and various challenges. Artificial intelligence applications, on the other hand, can provide educational materials and methods suitable for the individual needs of each student.

With the increasing use of artificial intelligence technologies in the field of education, various ethical issues such as privacy, surveillance and bias have come to the fore. The most prominent of these issues is the protection and privacy of individuals' personal data. The fact that artificial intelligence systems collect and analyze students' personal data has raised the issue of privacy (Akgun & Greenhow, 2022). The capacity of AI to predict students' future preferences and actions raises ethical concerns.

LIMITATIONS and RECOMMENDATIONS

Researchers who want to conduct studies on artificial intelligence in the field of education will be able to identify internationally important sources, authors, institutions, countries and keywords in the light of the findings of this study. Keyword analysis will provide practicality for researchers to customize their research topics. Web of Science database, which provides access to effective and up-to-date publications, was used in the research and the research was limited to this database. This research topic can become more comprehensive with other databases. The research was conducted in May 2024 and the study can be repeated in the future to get healthier results for the year 2024. In this study, a bibliometric analysis of the studies on artificial intelligence in the field of education was conducted. Today, bibliometric analysis studies can be conducted on ChatGPT, an artificial intelligence tool that is increasing in popularity in the field of educational sciences.

According to the results of the analysis, the important issue of ethics related to the subject can also be made a research topic. Analyses can be made on issues such as prejudices and data privacy

related to artificial intelligence in the field of education. Studies can be conducted on how AI-supported education systems can be designed within the framework of ethical principles. A current research can be conducted to develop policy recommendations to increase the use of artificial intelligence in education and to eliminate prejudices against artificial intelligence. According to the results of the analysis, current research on machine learning can be conducted. It can be examined how differences in education systems affect artificial intelligence research areas. Differences in the trends of research on artificial intelligence in the field of education in developed and developing countries can be examined. Research can be conducted on the problems faced by teachers in using artificial intelligence tools. Research can be conducted to develop special artificial intelligence applications for students with learning difficulties.

As a result of the findings presented in the research, it is possible to say that the studies on the use of artificial intelligence in the category of education have increased over time and as a result, a wide research scope will exist in educational sciences. This scope will be a factor in updating and shaping the policies of academic studies and educational sciences.

Ethics Committee Approval

Ethics committee approval was not obtained because data from previously published studies were used in the study. Ethical principles and rules were followed throughout the study.

Author Contributions

The contribution rate of the authors is equal.

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This study was not supported by any institution.

Conflict of Interest

There is no conflict of interest between the authors.

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