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Research Article

# The Adventure of Artificial Intelligence in Educational Research from the Past to the Present

Deniz Kaya

Nevşehir Hacı Bektaş Veli University, Faculty of Education, Nevşehir, Türkiye, denizkaya@nevsehir.edu.tr

**Abstract:** This study aims to examine scientific studies on artificial intelligence (AI) in educational research from the past to the present, based on the Web of Science database. In this context, 1465 scientific articles containing AI in education from the past to the present were evaluated. Articles accessed from the WoS database were examined using a bibliometric analysis method according to productivity, network analyses, conceptual structure, and thematic map titles. Within the scope of productivity, authors, institutions, countries, citations within the scope of network analysis, authors, institutions, sources, and countries were included in the analysis. In addition, thematic changes over the years, word cloud, collaborations, conceptual formations, and thematic mapping were carried out based on keywords. In this context, 1465 scientific articles published by 3783 authors representing 86 countries were included in the research. According to the research findings, the number of studies and citations on AI in education has increased significantly, especially in the last five years. The Education University and The Chinese University of Hong Kong stand out as productive institutions. While China, England, and the USA stand out as the countries of responsible authors, Hwang, G. J., stands out as the author of network analysis, and the Computer Education journal stands out as the journal. As a thematic change in the studies, there has been an evolution towards new technological developments such as deep learning, machine learning, ChatGPT, chatbots, learning analytics, blockchain, and generative AI. According to the factor analysis conducted on the conceptual structure of AI-related studies in education, it was determined that it explained 48% of the total variability. According to the study findings, studies on AI applications in education should be enriched from a disciplinary perspective, and efficiency should be increased regarding their reflections on teaching.

**Keywords:** Artificial Intelligence (AI), Bibliometric Analysis, Educational Research, Web of Science (WoS)

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## 1. Introduction

Innovative technological research is undoubtedly one of the main components that make countries stand out in global competition. In this regard, strengthening scientific and technological capacity and sustaining the technology ecosystem has become inevitable for many nations. With the technological developments in recent years, concepts such as artificial intelligence (AI), internet of things (IoT), robotic coding, blockchain, metaverse, big data, nanotechnology, digital change, and virtual reality have become increasingly prevalent in our lives, and there is an increasing interest in these areas. Changes that require AI technologies, especially voice recognition, facial recognition, and autonomous vehicles, are significantly affecting societies' lives (Huang & Qiao, 2024). The rapid advancement of technology causes changes in habits on a global scale and the differentiations of ways of connecting, interacting, reading, writing, and being informed (Hinojo-Lucena et al., 2019). So much so that, thanks to the successful applications of AI, there is a sharp evolution towards adaptive intelligence software, and the application areas of innovative products are diversifying at a rapid pace, demonstrating the breadth of its impact. As in many disciplines, the effects of innovative technological concepts are strongly felt in education. Especially under AI, virtual digitalization, big data, and IoT, encouraging the speed of modernization of the ecological structure of education systems comes to the fore (Huang et al., 2021a). With a better understanding of the potential capabilities of productive AI, individuals' learning knowledge is expanded by producing quality content. For this reason, there is a sharp evolution towards an AI society that individuals can easily experience anytime and anywhere. We are witnessing the inevitable rise of AI applications in many areas, such as personalized online education systems, medical

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services, agriculture, manufacturing, communication, media, transportation, defense, communications, logistics, weather (Organisation for Economic Co-operation and Development [OECD], 2019). In education, as in many fields, the effects of AI-based applications are felt better and included in learning environments with innovative applications.

Today, the necessity of nations redesigning their education policies is increasing due to the values that AI-based technological transformations add to learning. It has been observed that AI-based new-generation technologies in education provide successful pedagogical results with the help of various applications such as content presentation, feedback, and progress control with an intelligent teacher (Bayne, 2015; Chen et al., 2022). For this reason, AI, a machine-based technique with algorithmic power, has been frequently included in education in recent years to support learning in various contexts (Hwang et al., 2020). There is increasing focus on applying AI technology to create intelligent campuses, assist education, and efficiently carry out learning by producing intelligent learning-teach algorithms (Huang et al., 2021b). Therefore, it has been essential to understand AI-related issues in education over the years, determine general trends, and provide suggestions for future researchers.

## 1.1. Conceptual framework

### 1.1.1. Artificial intelligence

AI is a new-generation technology product that refers to imitating basic abilities such as thinking, learning, and decision-making that distinguish humans from other living things through electronic devices, especially computers. AI, also called machine intelligence, is a sub-branch of computer science that focuses on producing a new type of intelligent machine that simulates human intelligence (Huang & Qiao, 2024). The concept of AI is computer systems that can perform human-specific processes such as learning, adaptation, synthesis, self-correction, and use of data for complex processing tasks. (Popenici & Kerr, 2017). In other words, a processor with tremendous capabilities includes adaptive behaviors and human-like cognitive and functional abilities (Chen et al., 2020). AI, a strategic technology, is pioneering a new era in technological, industrial, or social fields, creating significant and far-reaching effects on education, economic, and social situations (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2021). The proposed concept of artificial neural networks fueled the origin of these effects. Artificial neural networks were designed by McCulloch and Pitts in 1943 as an algorithmic model that took the functionality of the human brain into account and was organized as a system structure consisting of a large number of neurons connected in parallel and interacting with real-world examples (Kohonen, 2001). In this regard, the development of AI is not problem-free, and the lack of methodology is always felt due to widespread expectations.

AI permeates every layer of our lives and is reflected in many disciplines. Considering that AI and human intelligence coexist, there will not be a field of work in the future where the impact of AI is not felt and its impact is not mentioned. AI, which has a versatile impact on all areas, including purpose, content, method, and evaluation system, also has multidimensional effects on education (Paek & Kim, 2021). Today, AI applications solve real-world problems in six areas: computer vision, machine learning, natural language processing, cognition and reasoning, robotics, games, and ethics (Huang & Qiao, 2024). In this regard, AI is built on three growth factors: algorithms, big data, and computing power. Especially in the early 21st century, the increase in data volume with the widespread use of smartphone applications and the diversification of the number of tools with algorithm extensions has significantly contributed to the development of AI (Russell & Norvig, 2021). Thanks to machine learning and deep learning breakthroughs in AI-based technologies, as structures containing big data, cloud computing, and related computing and storage performance become available, AI's performance and impact areas increase daily (Chatti et al., 2012; Garcia et al., 2007; OECD, 2019).

### 1.1.2. Artificial intelligence in education

In today's information age, the first quarter of which we are only experiencing, radical reforms are being experienced in education with the rapid development of AI technologies (Huang et al., 2021a, 2021b). In particular, the fact that AI applications require a multifaceted disciplinary perspective, such as science, mathematics, sociology, psychology, engineering, philosophy, and geography, accelerates the transformation of these reforms. AI applications that impact many areas of our lives are frequently encountered in education (Bozkurt et al., 2021). Among the primary reasons for using AI in educational environments is to produce effective, qualified, high-quality, and fast solutions to problems encountered in daily life. For this reason, personalized systems, software, ontologies, and semantic web techniques stand out as areas of use for AI in education (Lemaignan et al., 2017). According to Yang and Zhang (2019), AI in intelligent teaching systems can determine learning performance, knowledge level, intelligence level, preferences, learning style, learning behavior, and cognitive, affective, and cultural factors. Therefore, the reflections of AI applications on education can be evaluated multifacetedly. Drawing attention to this situation, Chen et al. (2020) state that AI significantly impacts the education sector, especially in management, teaching, and learning. This is because AI can be organized as a learning material according to student needs, enables personal learning, and has the potential for a better learning experience. In addition, AI-supported educational environments allow for analyzing student participation, identifying at-risk students full-time, and shortening the intervention time in the learning environment (Chen et al., 2022; Hwang et al., 2020; Tsai et al., 2020).

Today, AI applications in education are accepted in many areas. AI applications are increasing in popularity today in order to promote fair and qualified progress in education and to determine their benefits for teachers and learning (Wang et al., 2023). Creating applications that increase individual learning capacity, developing personalized learning resources, and enriching the perception of learning with simulated scenarios can be cited as the contributions of AI to education (Shi et al., 2024; Xie et al., 2019). Many researchers; believe that the use of AI in education will improve their students' digital literacy, knowledge, collaboration, learning abilities, and academic perceptions (Huang, 2021; Lee & Lee, 2021; Wang et al., 2023). It includes improving the preferred AI learning effects and teaching mode in education and basic AI knowledge and how it will interact (Huang & Qiao, 2024). In this context, numerous research outputs focusing on the application of AI in education suggest that AI will become a technical tool with much stronger potential for future learners and educators (Chatti et al., 2012; Garcia et al., 2007; Paek & Kim, 2021; Wang et al., 2023). Image and face recognition, adaptive learning, and other AI-based technological applications provide a learning experience, increase efficiency, and offer a different educational perspective (Cui et al., 2018; Hwang & Tu, 2021). For this reason, the role of AI applications in education is increasing daily.

### 1.1.3. Literature review on artificial intelligence in educational research

Although AI first emerged in the mid-20th century, studies/research in this field have recently gained significant momentum. Although there is increasing interest in AI and its applications, more studies need to be reviewed to investigate the use of AI in education. When research on AI in education is generally evaluated, it can be seen that issues such as the development of computational thinking skills through AI (Huang & Qiao, 2024), curriculum design based on AI (Chiu & Chai, 2020), the potential of sports applications in physical education (Lee & Lee, 2021), nursing pain education (Harmon et al., 2021), the role of AI in mathematics education (Hwang & Tu, 2021), the association of AI and virtual reality (Lin et al., 2021), AI and flipped learning-based mental health education (Shan & Liu, 2021), students' flow experience and learning effectiveness (Shi et al., 2024), intelligent homework grading and brilliant question answering systems (Tobler, 2024), offline course applications (Li & Wang, 2021), and ethics in the use of AI (UNESCO, 2021) are discussed. Common indicators of these studies include the fact that productive AI-based applications positively affect students' learning intentions (Lin et al., 2021;

Shan & Liu, 2021), promote the modernization of education by providing enriched learning resources (Zhao et al., 2023), improve students' performance by attracting their attention (Li & Wang, 2021; Shan & Liu, 2021; Wang et al., 2023), enhance creativity, offer a live learning experience, increase self-efficacy and improve digital literacy (Garcia et al., 2007; Wang et al., 2023).

We see evaluations from different perspectives when we look at similar studies in the literature. For example, Bozkurt et al. (2021) systematically examined AI studies in education in half a century (1970-2020). According to the study's findings, there has been a significant increase in the number of studies involving AI in recent years, and this trend will probably increase in the coming years. Data obtained from WoS and Scopus databases were used in the bibliometric analysis study conducted by Hinojo-Lucena et al. (2019). According to the findings, AI studies need to be at a sufficient level to allow the production of scientific content. It has been stated that the USA stands out in productivity with the University of Alicante, Polytechnic University of Valencia, Autonomous University of Madrid, and University of Alcala institutions. In the bibliometric and content analysis study conducted by Bahroun et al. (2023), 207 research articles were examined. At the end of the study, it was reported that ChatGPT has emerged as a dominant generative AI tool and that there is an exponential increase in generative AI. The systematic review conducted by Forero-Corba and Negre-Bennasar (2024) examined studies on machine learning and AI. Fifty-five articles obtained from WoS and Scopus databases were examined. According to the findings, using machine learning and AI has strong effects. As a result of the study conducted by Paek and Kim (2021) based on the WoS database, it was determined that AI studies have increased dramatically in the last 20 years. At the same time, it has been reported that the issues related to AI education technology and measurement and evaluation are up-to-date. Chen et al. (2022) tried to determine the trends and topics related to AI by examining 4519 publications between 2000 and 2019. According to the research findings, it has been stated that the interest in using AI for educational purposes has increased, and the subjects of intelligent lesson systems, language education systems, educational robots, educational data mining for performance prediction, discourse analysis in collaborative learning, and teaching evaluation have come to the fore.

### 1.2. Purpose of the study

Technological developments deeply affect nations' perspectives on education and training. In this regard, having the competencies required by the information age and keeping up with innovative changes has become inevitable. Considering the increasing interest in AI-based applications, especially in the last decade, the combination of education and technology is felt more intensely. Therefore, it is essential to know the reflections of the studies on AI applications, which have influenced education worldwide. Future research is essential to holistically reveal AI-related studies' trends, impact, and potential, especially in the relevant literature. In this regard, the bibliometric analysis approach, which allows us to examine all aspects of the studies from past to present, helps us. Bibliometric-based research includes much quantitative information such as subject headings, contents, keywords, publication language, author, co-authors, authors' institution, authors' countries, reference information, reference impact levels, citations, co-citations, and year of publication. This type of research contributes to obtaining scientific findings with the help of quantitative analysis on the determined subject and allows the application of many different quantitative analysis methods. Bibliometrics supports statistically presenting information about the subject of study. It helps to present the importance of the subject in the literature to the readers quantitatively (Zhao & Strotmann, 2015). Such research provides valuable data to field experts, readers, and program makers by evaluating scientific content from many aspects. Given all the explanations, the study's starting point is to determine the general change, development, direction, and impact of AI-based studies in educational research. It is essential to know the general structure of the research topic in the relevant field and to reveal the needs by following it periodically. Therefore, it is hoped that this comprehensive research will constitute an essential

resource in the field, guide future research, and give ideas to experts in different disciplines. In addition, it is expected to accelerate research in similar directions and allow us to see the changes in the process better. This study evaluated articles containing AI in educational research indexed in the WoS database according to performance-based descriptive findings, network analyses, conceptual structure, and thematic mapping, and answers to the following research questions (RQs) were sought:

RQ 1. What is the change in AI-related research in education according to years and citation numbers?
RQ 2. What are the authors, resources, institutions, and countries that contribute to AI-related research in education?
RQ 3. Which authors and sources interact in AI-related research in education?
RQ 4. How does the collaborative profile of authors, institutions, and countries regarding AI-related research in education change?
RQ 5. How do common keyword and co-occurrence profiles change in AI-related research in education?
RQ 6. What are the trending topics and thematic changes in AI-related research in education?
RQ 7. How do the general conceptual structure and thematic mapping change in AI-related research in education?

## 2. Methodology

### 2.1. Research design

In this research, scientific articles published on AI from the past to the present were examined in a descriptive and cross-sectional retrospective manner with the help of bibliometric analysis. Bibliometric analysis was used in the research, making it possible to examine the scientific literature and researchers who contribute to it according to statistical procedures. This analysis provides a holistic perspective by creating a road map for readers and researchers regarding the determined research topic (Chen et al., 2019). In this analysis, applications are made according to the criteria determined by the data set created using quantitative techniques (Pritchard, 1969). One of the purposes of bibliometric analysis is to summarize an extensive data set in the context of specific criteria (Donthu et al., 2021). These analyses involve collecting, processing, and evaluating publications with scientific content (Verbeek et al., 2002). Bibliometrics is a practical application, especially in better defining and distinguishing the field (Donthu et al., 2021). Bibliometric analysis involves dynamics and structure (Chaparro & Rojas-Galeano, 2021). In dynamic analysis, indicators such as publications, citations, authors, keywords, and terms are examined within the scope of the scientific production network, and in structure analysis, indicators such as conceptual, interaction network, thematic change, and network are examined (Jamali et al., 2022). This analysis technique allows the evaluation of research results and examines scientific outputs comprehensively (Grzybowska & Awasthi, 2020). This study conducted bibliometric analyses according to performance (scientific productivity), network analysis, conceptual structure, and thematic mapping. In this regard, according to the research framework proposed by Arksey and O'Malley (2005), first, the research question was defined, the database was decided to create the data set related to the research topic, the database was accessed, the criteria to be used in data selection were determined, and a data set was created from the database, the data set was analyzed, the analyzes were evaluated, the findings were reported, and the processes were reviewed by providing interpretation of the findings. Process information, including the basic framework of the research, is given below (Figure 1).

**Figure 1**

*The Basic Framework of the Research*


## 2.2. Data collection and procedure

Web of Science™ Core Collection database was used to create the data set of educational studies with AI content. The Web of Science (WoS) database contains research categories with many options for analyzing published documents. This database includes many disciplines and provides reliable data with advanced search options. It also allows statistical analysis and quantitative techniques suitable for bibliometric analysis. The strengths of the WoS™ database include being easy to access, containing prestigious journals, being suitable for downloading appropriate data from analysis programs, allowing detailed searches in categories, being compatible with the programming language, containing reference information, and having an open-source representation (Web of Science Group [WoSG], 2024). The WoS™ database has been designed using a structure within Clarivate Analytics. Its many working areas have gained a respected place worldwide, allowing researchers to examine and record in-depth (Fang et al., 2017). To create the data set of the research, the Topic (search title, abstract, and author keywords) module was considered. Accordingly, a search was made in the WoS™ database for scientific records related to research on AI with educational content. The process followed to obtain scientific records is as follows: WoS™ Database: *[TITLE-ABS-KEY ("artificial intelligence") AND (educat* OR learn* OR teach* OR class* OR innovat* OR student*) Refined by: Document Type: (Article), Language: (English) and Years of Publication: All years, and Science Categories: (Education Educational Research) and Web of Science Index: (Social Science Citation Index (SSCI), Science Citation Index-Expanded (SCI-Expanded), Emerging Sources Citations Index (ESCI), Arts & Humanities Citation Index (A&HCI)].* The figure reflecting the screening criteria performed to create the data set is shown below (Figure 2).

**Figure 2**

*Information Including the Criteria of the Screening*


Documents downloaded from the WoS™ database are saved in the specified folder in "plain text" format. This file format works and is compatible with VOSviewer and RStudio applications. The WoS™ database allows downloading up to 1000 documents. These floating two separate files were downloaded and merged into one. This final data set was used for bibliometric analysis.

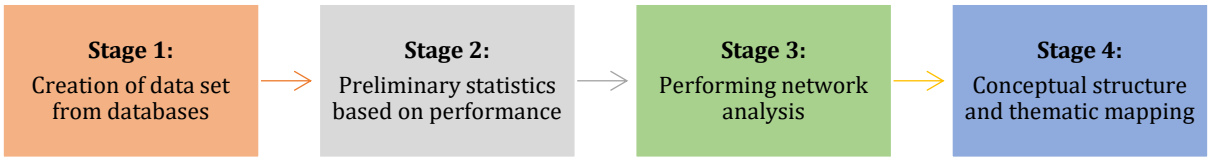
## 2.3. Data analysis process

Data obtained from the WoS™ Core Collection database was analyzed bibliometrically. The preferred bibliometric analysis application for the research topic consists of four stages. In the first stage, the data

set intended for research was accessed from the database. When the selection was made according to the criteria [*WoS™ Index: SSCI, SCI-Expanded, ESCI, A&HCI; Subject Area: Education & Educational Research; Document Type: Articles, Language: English; Publication Period: Past to the Present (15.04.2024)],* it was determined that there were 1465 scientific documents. At this stage, the data was checked and examined to determine whether there was any duplicate data. In the second stage, performance-based analyses were carried out. In this context, the annual number of publications and citations, the most published authors, the most cited studies, the distribution of responsible authors by country, the distribution of dominant authors by year, and the institutions with the most publications were examined. In the third stage, network analyses (analyses were used to include cited common citation, common author, geographical atlas, common word, trend topic, and thematic changes) were used. In the last stage, analyses were made according to conceptual formations and thematic mapping. The general structure, including the analysis, is presented below (Figure 3).

**Figure 3**

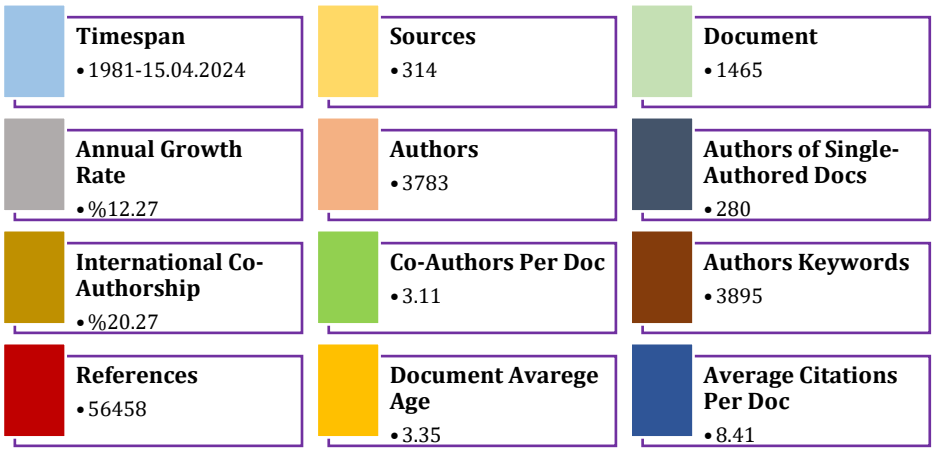
*General Structure Including Analysis*




VOSviewer 1.6.18 software was used to analyze research data, which allows dynamic and structured analyses of large volumes of data (Van Eck & Waltman, 2010). The VOSviewer program uses labels and circular structures when visualizing network analyses. The weighting of the element, depending on the volume of the circle size, is calculated with the help of different colors, and similar elements are divided into clusters (Yuan et al., 2021). The amount of interaction depends on the intensity of the relationship between each cluster. The R programming language, which allows the data set to be examined from many aspects, was used to investigate conceptual and thematic changes. Thanks to this programming language, many contents can be analyzed, such as dominant authors by year, conceptual formations, thematic changes, geographical view word formations, transformational differences, and formations between countries related to the research subject (Aria & Cuccurullo, 2017). VOSviewer [https://www.vosviewer.com] and R-tool [www.rstudio.com], which are open-access and free applications that are frequently preferred in bibliometrics-related research, allow both in-depth and visualization of the given data (Van Eck & Waltman, 2010). Information containing a comprehensive view of the dataset using RStudio (biblioshiny) is presented in Figure 4.

**Figure 4**

*A Comprehensive View of the Dataset*



As shown in Figure 4, 1465 scientific articles containing AI in education were written by 3783 authors, according to the criteria determined from 1981 to the present [15.04.2024]. The number of scientific articles with a single author was 280, the collaboration index between authors was 3.11, the international collaboration index was 20.27%, the annual growth rate was 12.27%, the average number of citations was 8.41, the number of references was 56458 and document average age was 3.35. The thematic and strategic diagram technique in analyzing selected scientific studies creates dynamic clusters by analyzing key or co-axial words (Law et al., 1988). These clusters provide information about the general view of the research topic (Gonzales-Valiente, 2019). On the other hand, conceptual maps created regarding the determined research topic divide the content of the total data set into information sets and produce comprehensive results about the research content and trend (Wetzstein et al., 2019). This way, qualified findings are obtained to better organize future research areas and reveal different research patterns. In this context, the research analyzed data holistically by considering descriptive, social network, conceptual structure, and thematic changes.

### 2.4. Validity and reliability

Reliability and validity studies are among the basic requirements of research. First of all, to increase the research's validity, care was taken to express the actions taken regarding the research data process in detail. In this regard, it is clearly stated which database the data will be obtained from, the website of the database, the date on which the data was collected, what criteria were used when searching for the data in the database, the keywords used in the data search, what restrictions were made in the search module and in what format the data was recorded. For the reliability of external validity, the steps taken in analyzing the data were specified, and information was given about the analysis programs applied. In addition, the justification of the methods used in data analysis and the factors taken into account in forming the data set are explained together with their reasons. Further contributing to reliability, the findings were presented directly, and it was ensured that the findings were holistic. In addition, the results obtained were supported by the relevant literature to increase consistency. In addition, information about the analysis programs used in the research and the web addresses where this software can be accessed are stated.

## 3. Findings

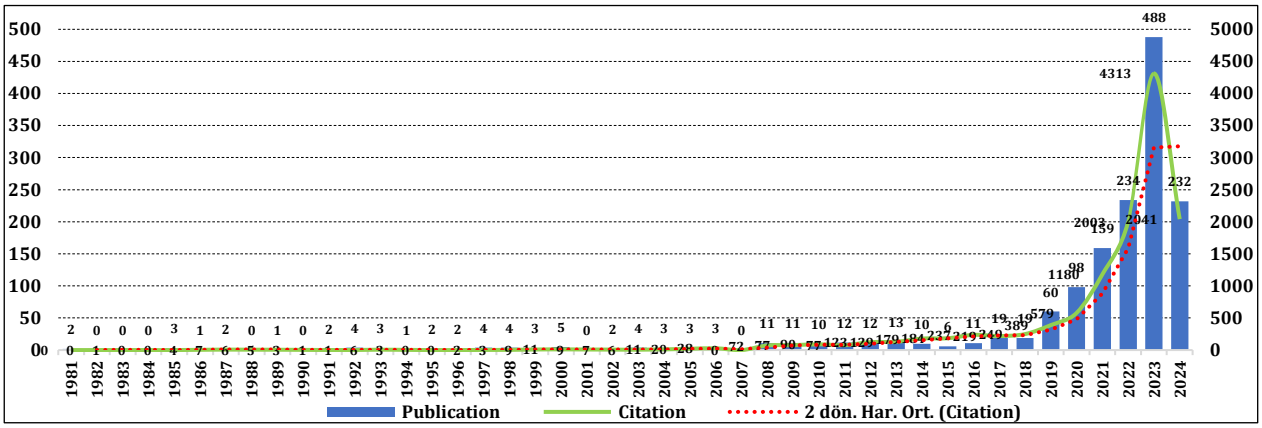
In this part of the study, the findings of AI-related research in the field of education, depending on the determined sub-problems, are presented with their explanations. First, under scientific productivity, AI-related research in education is distributed according to years, the number of citations, and the results for the most contributing authors, studies, institutions, and countries. Immediately afterward, findings from co-citation and co-author analyses are presented. Another title presents collaboration networks between institutions and countries and word cloud analyses under keyword and co-occurrence analysis. In addition, trending keywords and article titles of AI-related research in the field of education were analyzed under the title of trend topic and thematic change. Finally, the conceptual formations of published articles containing artificial intelligence in education are reported.

### 3.1. Scientific productivity on ai in educational research

The study reports the adventure of AI-related studies in education, according to the WoS database, from 1981 to the present, according to one year. In addition to the annual number of articles and citations in different colors, the harmonic average of the citation numbers is also included. In this context, the findings obtained according to the number of articles and citations registered in the WoS database from past to present are presented below (Figure 5).

**Figure 5**

*Annual Number of Publications and Citation in AI in Educational Research*




When Figure 5 is examined, it is seen that the number of articles containing AI in education has increased significantly, especially since 2019. There were almost no AI studies until 2019. Therefore, it is clear that there has been an increasing interest in this issue in the last five years. When we look at the number of citations, we see that there have been significant increases since 2019. Although there were very few studies on AI in the field of education between 1981 and 2019, it is noteworthy that there are significant increases in the number of articles and citations as we approach the present day. The table below lists prominent productive authors on AI-related work in education (Table 1).

**Table 1**

*Most Productive Core Authors on AI in Educational Research*

| Authors | Publications | Publications Fractionalized |
|---|---|---|
| Hwang, G. J. | 16 | 5.3 |
| Chui T. K. F. | 14 | 5.5 |
| Chai, C. S. | 12 | 2.6 |
| Gulson, K. N. | 9 | 3.8 |
| Ogata, H. | 9 | 2.1 |
| Su, J. H. | 9 | 3.7 |
| Xie, H. R. | 9 | 2.1 |
| Zou, D. | 9 | 2.1 |
| Tu, Y. F. | 8 | 2.1 |
| Chen, X. L. | 7 | 1.4 |
| Chu, S. K. W. | 7 | 2.1 |
| Dai, Y. | 7 | 2.2 |
| Lin, C. Y. | 7 | 2.2 |
| Mishra, P. | 7 | 2.3 |
| Chen, C. H. | 6 | 1.6 |

Table 1 shows authors producing on the subject of AI in education. These authors, also called core authors, direct the changes in the field and profoundly influence the studies carried out. Core authors produce approximately half of all publications in a research field and are known in bibliometrics as the Price Law [$M=0.749*(N_{max})^{1/2}$ (M= min. number of articles, $N_{max}$= number of articles by prolific author)] (Price, 1963; Yeoh et al., 2013). According to the relevant table of core authors, the number of articles published by Hwang, G. J. is the highest (as $N_{max}=16$). For this reason, the number of articles for which an author should be listed as a core author is calculated as three. The most productive authors are, Chui, (14), Chai, (12), Gulson, (9), Ogata, H. (9), Su, (9), Xie, (9), Zou, (9), Tu, (8), Chen, (7), Chu, (7), Dai, (7), Lin, (7), Mishra, (7) and Chen, (6) respectively. The table below lists the scientific articles that stand out in terms of citation count (Table 2).

**Table 2**

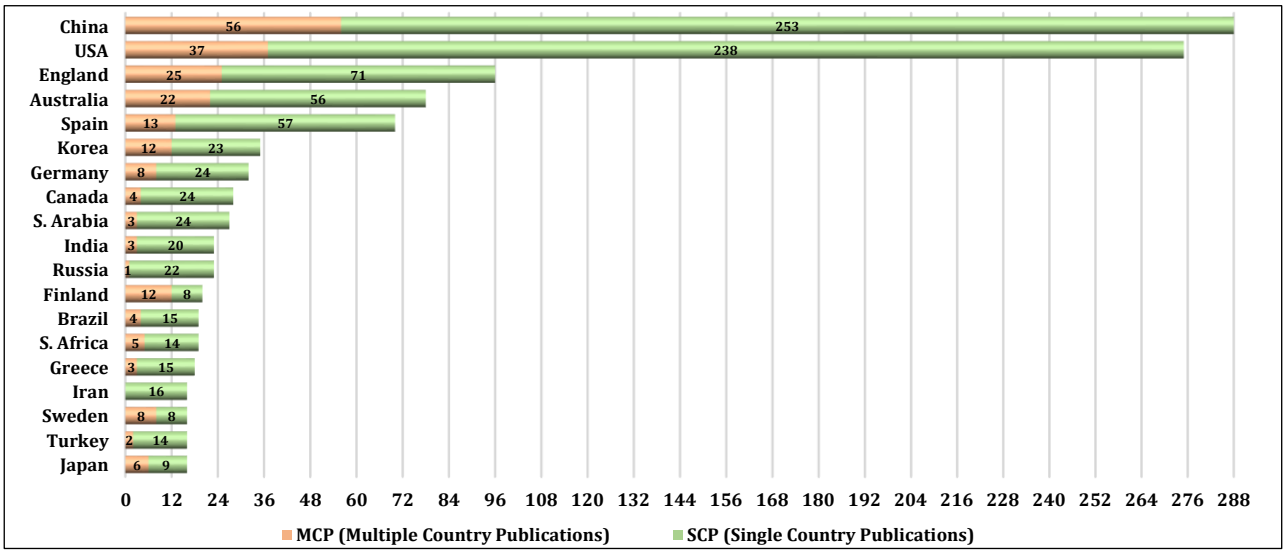
*Most Productive Core Authors on AI in Educational Research*

| Paper | Doi | Total Citations | TC per Year | Normalized TC |
|---|---|---|---|---|
| Chatti, M. A., 2012 | 10.1504/IJTEL.2012.051815 | 311 | 23.92 | 6.37 |
| Garcia, P., 2007 | 10.1016/j.compedu.2005.11.017 | 253 | 14.06 | 5.44 |
| Misyak, J. B., 2012 | 10.1111/j.1467-9922.2010.00626.x | 199 | 15.31 | 4.08 |
| Cotton, D. R. E., 2024 | 10.1080/14703297.2023.2190148 | 190 | 190.00 | 145.77 |
| Hwang, G. J., 2003 | 10.1016/S0360-1315(02)00121-5 | 183 | 8.32 | 2.13 |
| Tlili, A., 2023 | 10.1186/s40561-023-00237-x | 182 | 91.00 | 35.21 |
| Kessler, G., 2018 | 10.1111/flan.12318 | 139 | 19.86 | 5.83 |
| Goralski, M. A., 2020 | 10.1016/j.ijme.2019.100330 | 138 | 27.60 | 7.47 |
| Chou, C. Y., 2003 | 10.1016/S0360-1315(02)00130-6 | 125 | 5.68 | 1.46 |
| Chatterjee, S., 2020 | 10.1007/s10639-020-10159-7 | 110 | 22.00 | 5.95 |
| Farrokhnia, M., 2023 | 10.1080/14703297.2023.2195846 | 106 | 53.00 | 20.51 |
| Warschauer, M., 2008 | 10.1080/15544800701771580 | 105 | 6.18 | 4.25 |
| Cooper, G., 2023 | 10.1007/s10956-023-10039-y | 104 | 52.00 | 20.12 |
| Smith, R., 2010 | 10.1177/1046878109334330 | 99 | 6.60 | 3.30 |
| Lim, W. M., 2023 | 10.1016/j.ijme.2023.100790 | 98 | 49.00 | 18.96 |

When Table 2 is examined, the most cited article by Chatti et al. (2012) (23.92 citations per year) is the article titled "a reference model for learning analytics". This article is followed by articles written by Garcia et al. (2007) (14.06), Misyak and Christiansen (2012) (15.31), Cotton et al. (2024) (190.00), Hwang (2003) (8.32), Tlili et al. (2023) (91.00), Kessler, (2018) (19.86), Goralski and Tan (2020) (27.60), Chou et al. (2003) (5.68) and Chatterjee and Bhattacharjee (2020) (22.00) respectively. The figure below shows the distribution of authors by country (Figure 6).

**Figure 6**

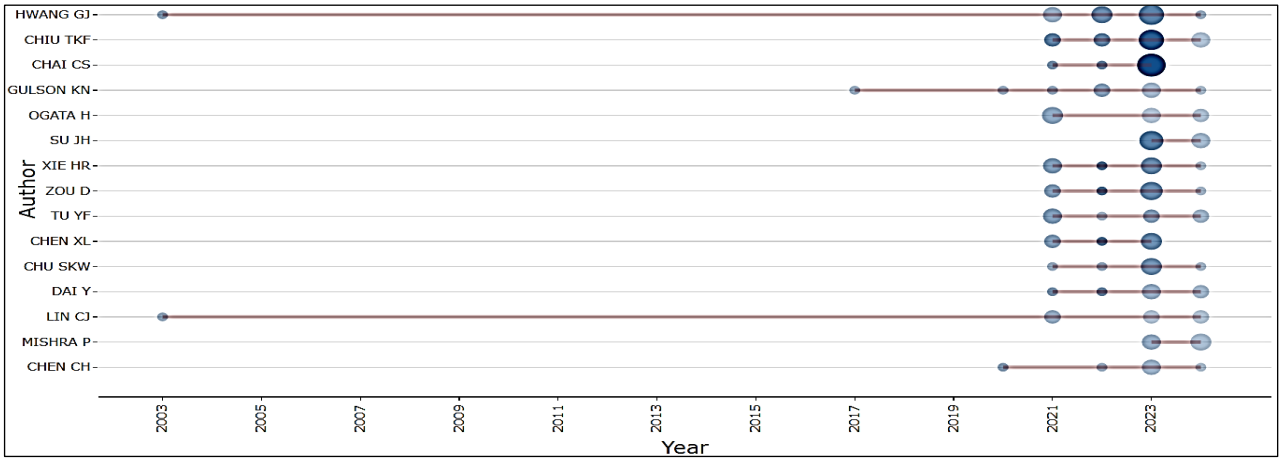
*Corresponding' Author's Country on AI in Educational Research*




When Figure 6 is examined, the authors who write articles on artificial intelligence in education are primarily from one country. The country with the most connections among authors writing articles on the specified research topic was China (*n*=309). This country is followed by USA (*n*=275), England (*n*=96), Australia (*n*=78), Spain (*n*=70), Korea (*n*=35), Germany (*n*=32), Canada (*n*=28), Saudi Arabia (*n*=27), India (*n*=23), Russia (*n*=23), Finland (*n*=20), Brazil (*n*=19), South Africa (*n*=19), Greece (*n*= 18), Iran (*n*=16), Sweden (*n*=16), Turkey (*n*=16) and Japan (*n*=15) respectively. The figure below shows the authors who took the dominant role in a specific period (Figure 7).

**Figure 7**

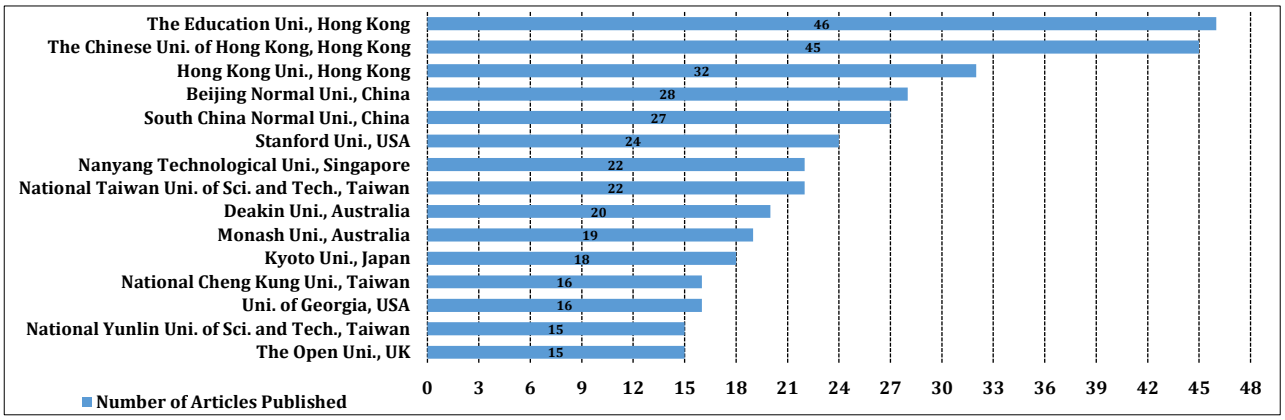
*Authors' Production Over Time on AI in Educational Research*




When Figure 7 is examined, the authors named Hwang, G. J. and Lin C. J., among the authors who have played the dominant role from past to present, were quite influential in the relevant field between 2003 and 2024. In the last three years (between 2021 and 2024), Chiu, T. K. F., Chai, C. S., Ogata, H., Su, J. H., Xie, H. R., Zou, D., Tu, Y. F., Chen, X. L., Chu, S. K. W., Dai, Y., authors stand out more. Between 2017 and 2024, authors named Gulson, K. N.; between 2023 and 2024, Mishra, P., took the dominant role. The figure below shows productive institutions on AI in education (Figure 8).

**Figure 8**

*Most Relevant Affiliations Over Time on AI in Educational Research*




When Figure 8 is examined, The Education (*n*=46) and The Chinese University of Hong Kong (*n*=45) are productive institutions in AI-related work in education. This is followed by institutions; Hong Kong (*n*=32), Beijing Normal (*n*=28), South China Normal (*n*=27), Stanford (*n*=24), Nanyang Technology (*n*=22), National Taiwan (*n*=22), Science and Technology (*n*=22), Deakin (*n*=20), Monash (*n*=19), Kyoto (*n*=18), National Cheng Kung (*n*=16), Georgia (*n*=16), National Yunlin (*n*=15) and The Open (*n*=15) respectively.

## 3.2. Network analysis on artificial intelligence

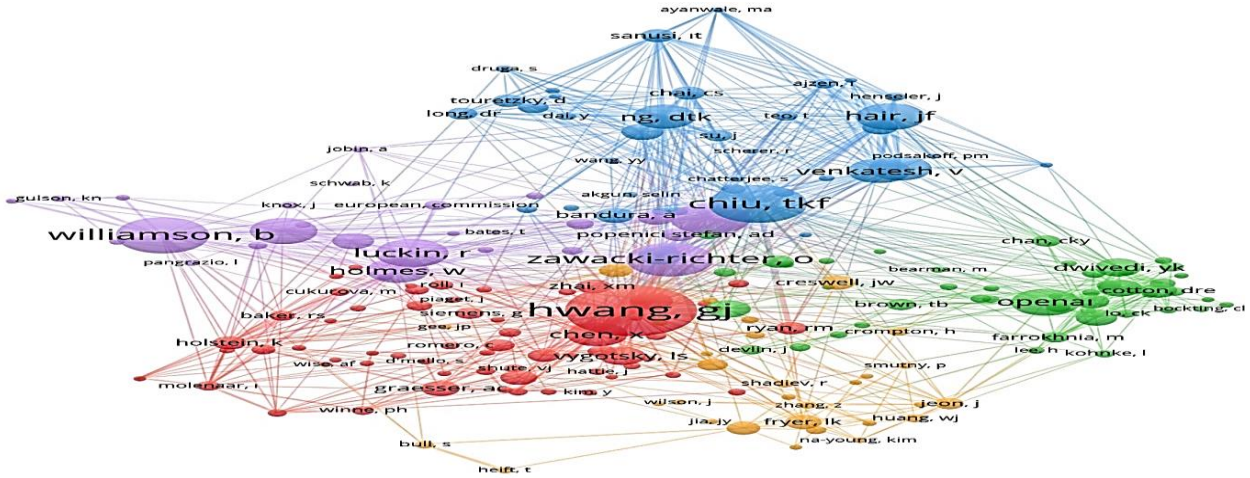
### 3.2.1. Co-Citation networks

Network analysis is an effective technique to reach essential findings in bibliometric research. Visualizations are made by including associations such as authors, countries, and references in the fictional structure of network analyses. In network analyses, co-citation network analyzes generally come to the fore, and the way two scientific articles are cited together is described as co-citation and is

shaped according to nodes and thicknesses in network visualization (Bağış, 2021). The criteria used for the visualization process are stated below the figures (Figure 9).

**Figure 9**

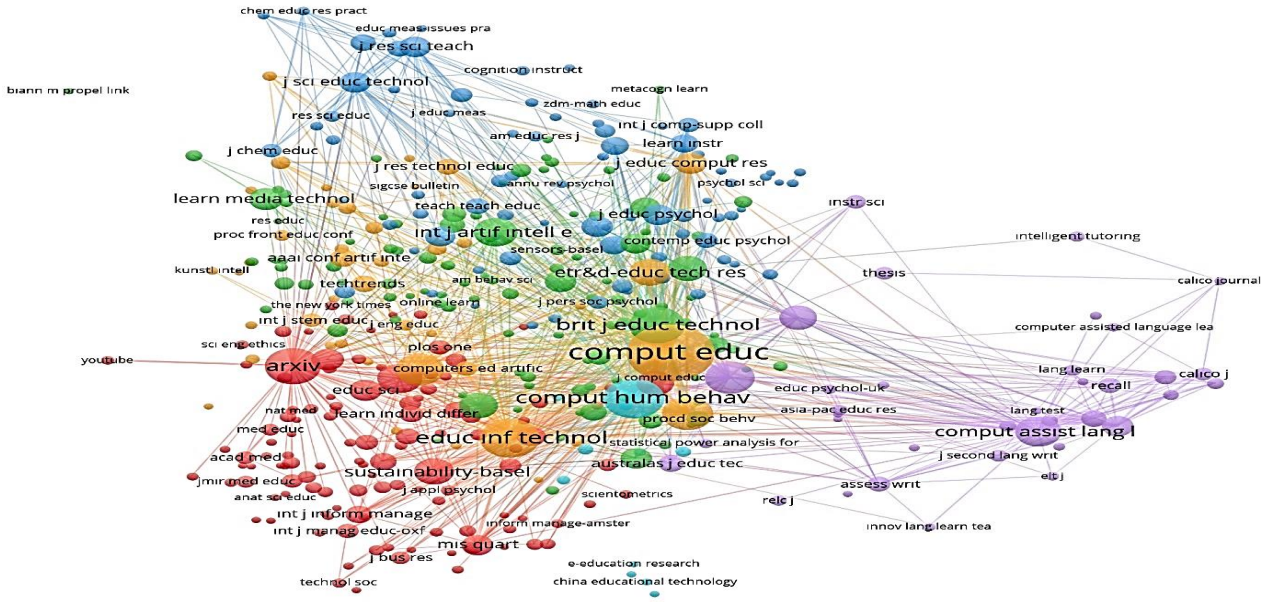
*Co-Cited Network Analysis in the Context of Cited Authors (≥20 articles)*




When Figure 9 is examined, according to the co-citation network analysis, network visualization occurred in five different clusters within the context of authors. The nodes formed between clusters and between authors within the cluster show the strength of the connections and indicate the influence of the authors in that cluster according to the node's width (Findlay & van Rensburg, 2018). For example, in the red cluster, Hwang and Chen influence the cluster as dominant authors and write articles on similar topics. On the other hand, in the purple cluster, Zawacki-Richter, Luckin, Williamson, Selwyn; in the green cluster, Openai, Dwivedi, Cotton, Cooper, and Tlili; in the blue cluster, Chiu, Venkatesh Cohen, Ng, and Hair; in the orange cluster, Fryer, Godwin-Jones, Zhang and Jeon authors stand out as the most influential authors of the clusters. These writers influence the cluster they are in and tend to anchor their community by directing both the cluster and other clusters with their study subjects (Mostafa, 2020). Below is a visualization of the co-citation network formed in the context of sources (Figure 10).

**Figure 10**

*Co-Cited Network Analysis in the Context of Cited Sources (≥20 articles)*



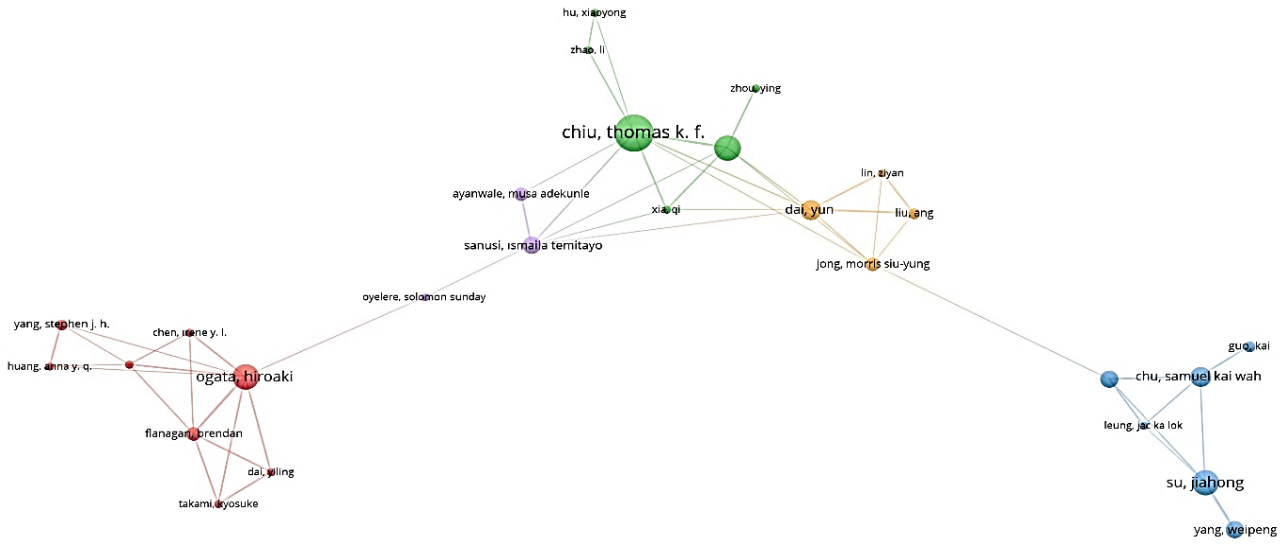
When Figure 10 is examined, according to the co-citation network analysis, network visualization occurs in six different colored clusters in the context of resources. Computer & Education in the orange cluster; Computers in Human Behavior in the light blue cluster; Educational Technology & Society, Computer Assisted Language Learning, Journal of Computer Assisted Learning, and The Language Learning Journal in the purple cluster; International Journal of Educational Technology in Higher Education and Science Education in the red cluster; British Journal of Educational Technology, International Journal of AI in Education in the green cluster; Review of Educational Research, Journal of Research in Science Teaching and Journal of Science Education and Technology in the blue cluster, resources interact intensively in their cluster. In this respect, these resources manage the changes in the field and influence the cluster in which they are located and other clusters.

### 3.2.2. Collaboration networks

In this part of the research, visualizations of collaborations on AI-related issues in the field of education are included. In this regard, within the scope of co-author analysis, the general view of the collaboration networks between authors, institutions, and countries is presented in visual form. The fictional nature of co-author collaboration means that more than one author contributes to writing a scientific article and naturally becomes a part of the work. In this respect, a detailed view of the social network structure between authors, institutions, and countries is obtained (Bağış, 2021). Below are the co-author network visualizations according to author, institution, and country criteria, respectively.

**Figure 11**

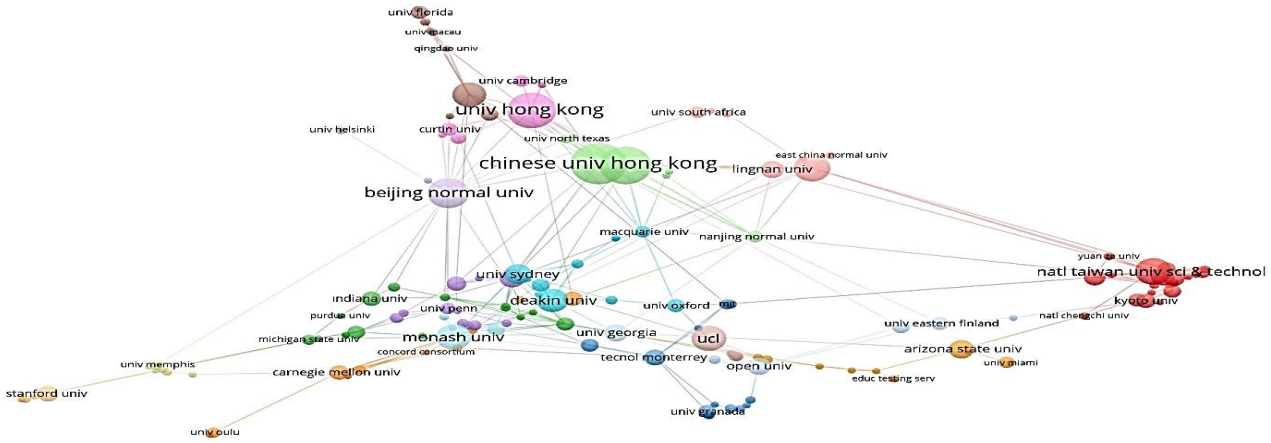
*Co-Authorship Network Analysis in the Context of Authors (≥3 articles)*




When Figure 11 is examined, it is seen that the collaboration between the authors is collected in five different clusters. However, there is no intense interaction in terms of both the width of the nodes and the connection strength. Accordingly, authors named Chiu dominate the green cluster, Ogata dominates the red cluster, Dai dominates the orange cluster, Su dominates the blue cluster, and Sanusi dominates the purple cluster. These authors have established limited interaction within their cluster. Therefore, there is not much cooperation and interaction between authors on AI in education. Collaborations between authors are generally between the same institution, university, Ministry of Education, and people living in the country, and geographical proximity also deeply affects collaborations. The author or authors who participate in this collaboration and are in a central position are described as "information brokers" and act as information disseminators (Park et al., 2015). Below is a visualization of the co-author network according to institution criteria (Figure 12).

**Figure 12**

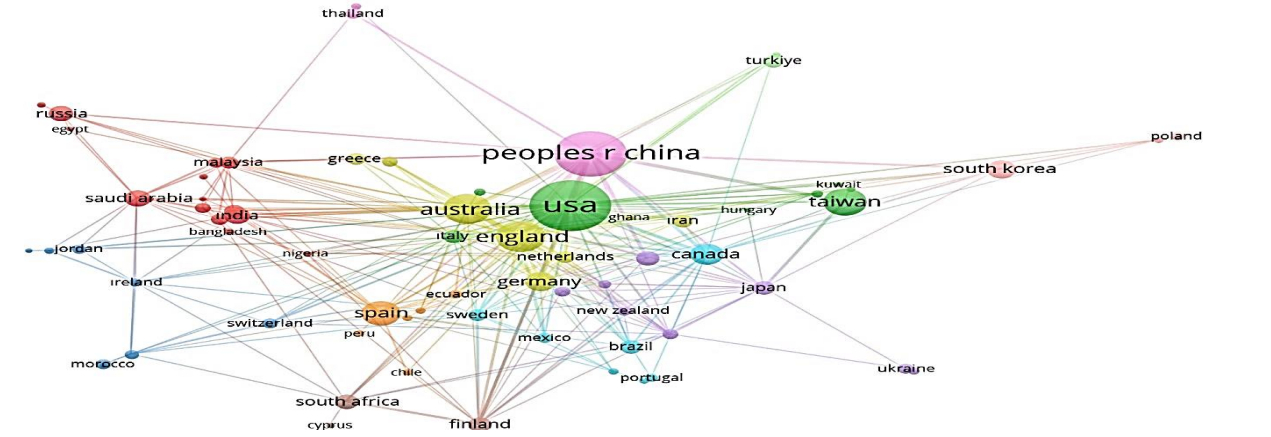
*Co-Authorship Network Analysis in the Context of Institutions (≥3 articles)*




When Figure 12 is examined, it is seen that the visualization of cooperation between institutions is divided into 17 different clusters. According to network analysis, The Chinese University of Hong Kong, Beijing Normal University, National Taiwan University of Science and Technology, National Cheng Kung University, Hong Kong University, Deakin University, Sydney University, South China Normal University and Monash University appear to be more productive in institutions' collaboration. One of the essential features of these institutions is that they are located in Far Eastern countries. Therefore, more emphasis is placed on AI applications in education, especially in Far Eastern countries. Below is a visualization of the co-author network according to country criteria (Figure 13).

**Figure 13**

*Co-Authorship Network Analysis in the Context of Countries (≥3 articles)*




When Figure 13 is examined, it is seen that the visualization of cooperation between countries is divided into 11 different clusters. According to network analysis, China, USA, Taiwan, Australia, England, Spain, India, Canada, Finland, South Africa, and Russia are the more prominent countries in cooperation. China, which is in the purple cluster, has cooperated chiefly with countries that are geographically closer to it, such as Thailand, Japan, Taiwan, and Singapore. The USA has cooperated chiefly with Australia, Canada, Taiwan, Colombia, and the Netherlands in the green cluster. India, which is in the red cluster, mainly cooperates with countries such as Saudi Arabia, Malaysia, Russia, and Bangladesh. According to the results of this analysis, geographical proximity has a significant impact on countries' cooperation. Similarly, the impact of cooperation can be mentioned in the context of developed and developing countries. Below is a visualization of the co-author network according to country criteria (Figure 14).

**Figure 14**

*Authors' World Collaboration Network on AI in Educational Research*

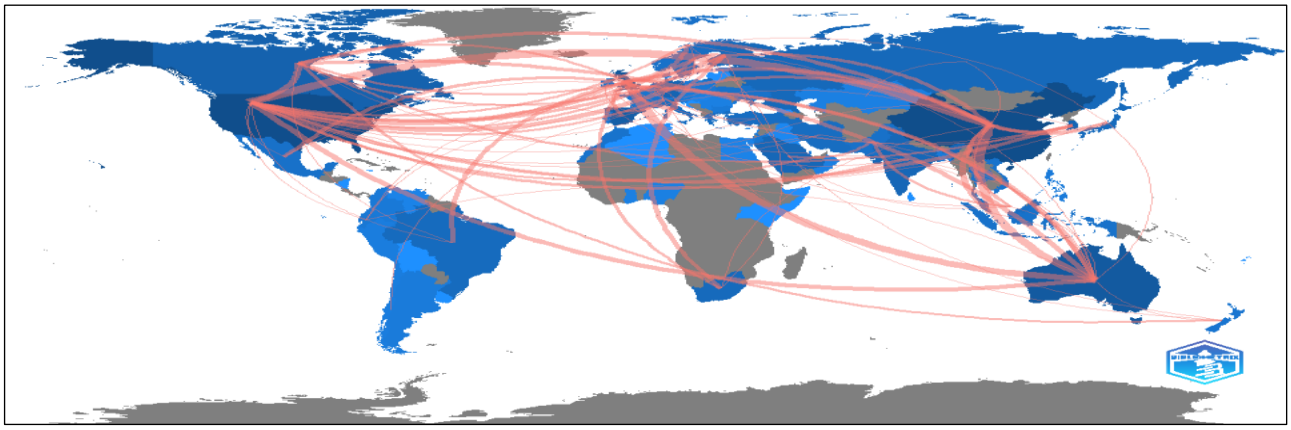


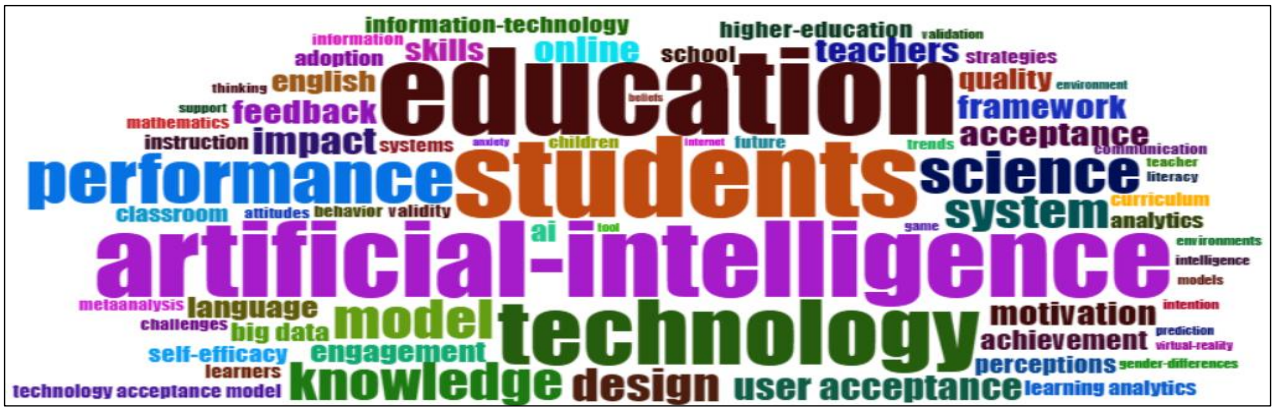
Figure 14 shows intense traffic in the co-network between countries. According to this cooperation network between countries, collaborations between China and the USA (*n*=28), between the UK and Australia (*n*=18), between China and Australia (*n*=16), between USA and Australia (*n*=10), between USA and Canada (*n*=9), between USA and Germany (*n*=8), between Australia and Germany (*n*=7), between China and Canada (*n*=7), between China and Japan (*n*=7), between China and Singapore (*n*=7), between China and UK (*n*=7), between Australia and Canada (*n*=6), and between UK and Germany (*n*=6) are more prominent. According to network relationship traffic, relationships between continents come to the fore. In particular, the intense network between countries in Asia, America, and Australia is noteworthy. According to network relationship traffic, relationships between continents come to the fore. In particular, more intense cooperation between countries in Asia, America, and Australia is noteworthy.

### 3.2.3. Keywords and co-occurrence network analysis

The keywords of the determined study topic give clues about the article's content and help access the desired documents. Keywords are highly preferred in bibliometric analyses due to their features and the basic framework of the analyses (Chen et al., 2023). In this bibliometric content research based on multifaceted analyses, word cloud analysis was conducted according to the keywords determined by the authors. In the fictional structure of the word cloud, textual data is visualized to obtain a view, and its value in research is determined depending on the predominant use of the word (Liao et al., 2019).

**Figure 15**

*Word Cloud for on AI in Educational Research (≤70, Keywords plus)*

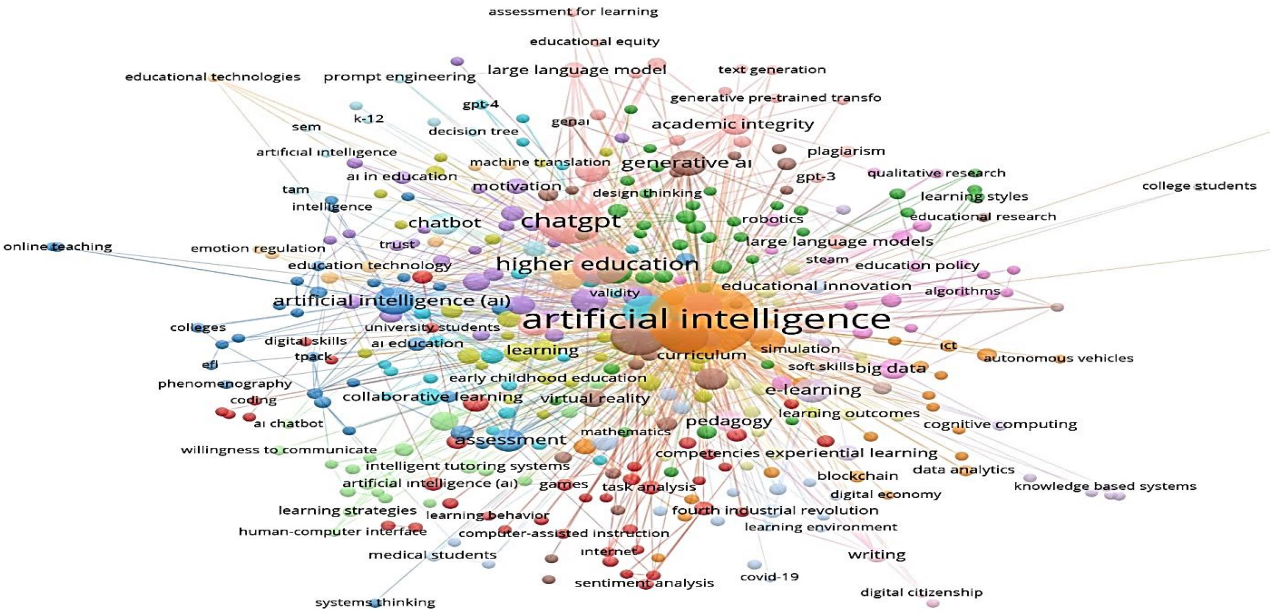



When Figure 15 is examined, the keywords frequently preferred by researchers related to the research topic are; *"education," "students," "artificial intelligence," "technology," "performance," "science," "model,"*

*"system," "design," "impact," "knowledge," "online," " user acceptance"* and *"teachers."* The number of common words was used to draw the general picture of AI-related research in education to determine in which areas the studies showed more tendencies and how frequently they were used. The visualization obtained from the common word network analysis is presented below (Figure 16).

**Figure 16**

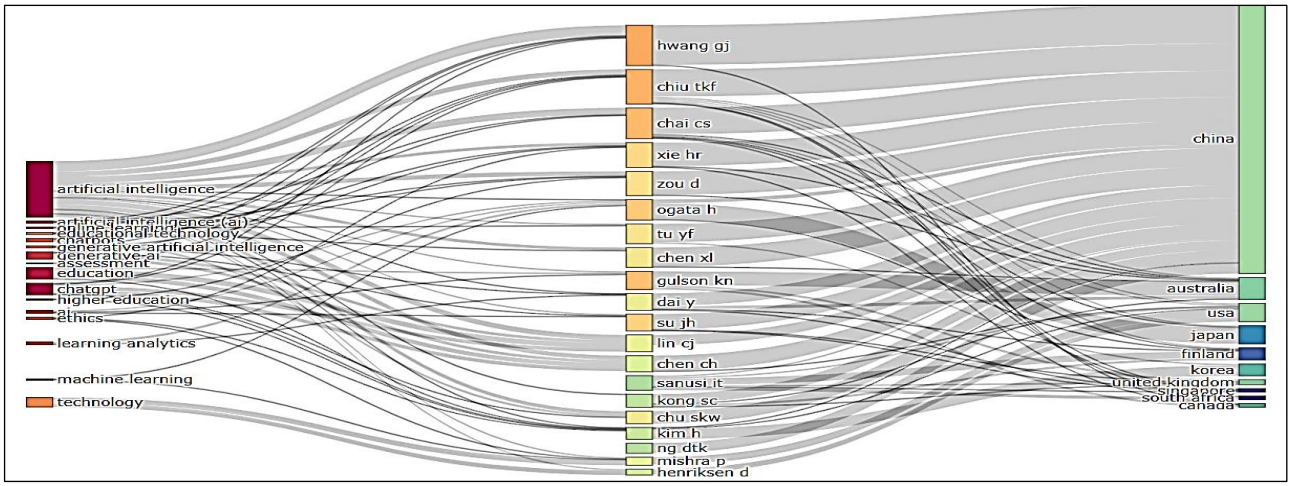
*Co-occurrence Network Analysis in the Context of Author Keywords (≥3)*




When Figure 16 is examined, it is seen that many clusters are formed in the keyword network analysis with AI content in the field of education. Especially in the orange cluster, the words *"artificial intelligence"* in the light brown cluster, *"ChatGPT," "higher education,"* in the brown cluster, *"generative artificial intelligence (GAI),"* and in the light blue cluster, *"machine learning"* come to the fore. These words also point to trends regarding the research topic and provide ideas for future researchers. Below is a three-plot (Sankey diagram) analysis (Figure 17). According to the results of the analysis, the authors are located in the middle of the figure, the contents are on the left, and the countries are on the right.

**Figure 17**

*Sankey Plot on AI in Educational Research (keywords- authors-countries)*



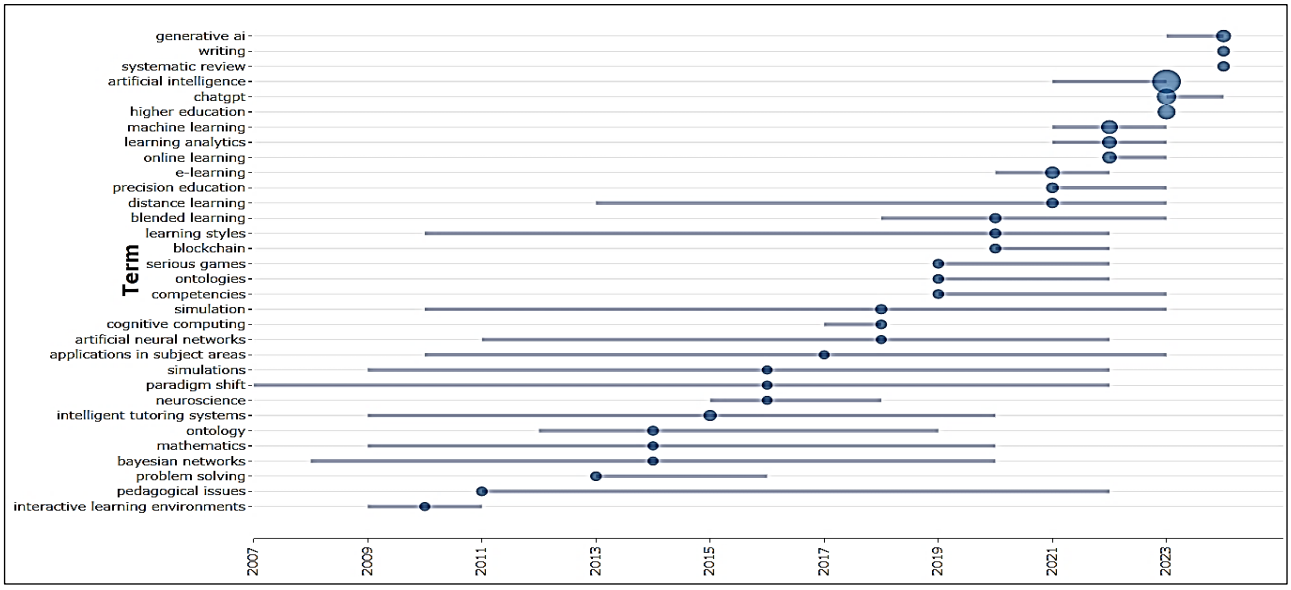
When Figure 17 is examined, the size of the boxes provides us with detailed and holistic information about the content, authors, and countries of the studies related to the research topic. Depending on the size of the boxes, the keyword *"artificial intelligence"* covers many authors and countries in many ways. Likewise, the keywords *"education"* and *"ChatGPT"* also have a widespread effect. When we look at the authors' category, the keywords used by the authors, such as Hwang, G. J., and Chiu T. K. F., significantly affect the field and direct the studies in the field. One of the strengths of studies in the field is that it is demonstrated that the countries that are influential in the research topic (China, Australia, USA, *etc.*) have a say in this field.

### 3.2.4. Trending topics and thematic evolution

In this section of the findings section, trending (prominent) topics related to the research topic and thematic changes determined depending on the topics are presented holistically. In this heading, the changes in AI-related studies in education from the past to the present have been analyzed over the years. Trend topics and thematic changes show which topics are more prominent in specific periods and hot spots in research (Chen et al., 2023; Mostafa, 2022). Below, the trend topics titles of research with AI content in educational research are presented (Figure 18).

**Figure 18**

*AI in Educational Research Topics Map*



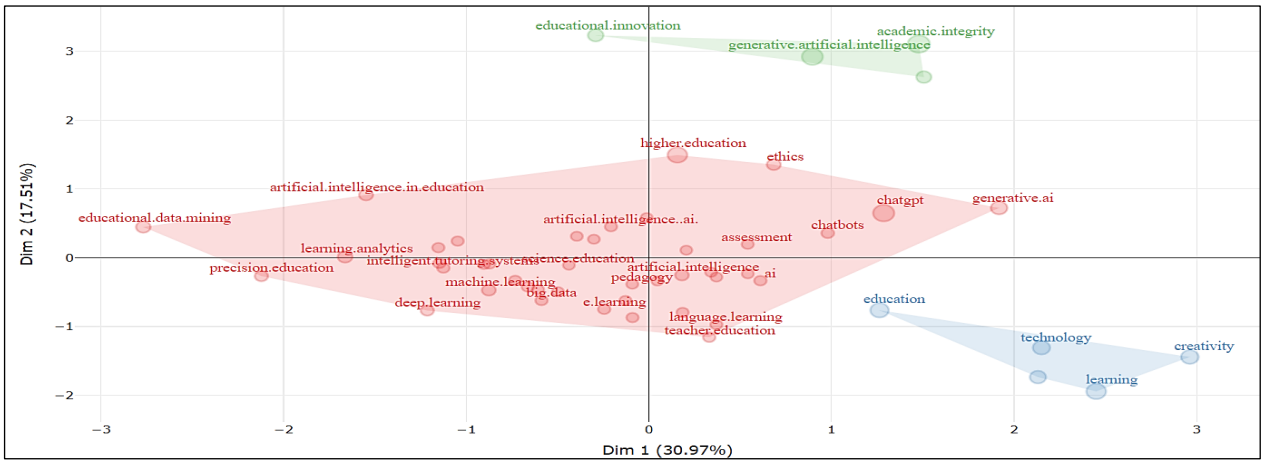

When Figure 18 is examined, it is seen that new generation technological content such as *"AI" (2021-2023), "ChatGPT" (2023-2024), "higher education" (2023-2024), "machine learning" (2021-2023), "GAI" (2023-2024), "learning analytics" (2021-2023), "e-learning" (2021-2023), "online learning" (2020-2022), "intelligent tutoring systems" (2009-2020), "distance learning" (2013-2023), "simulation" (2010-2023), "blended learning" (2018-2023)* and *"blockchain" (2020-2022)* are abundant. As we get closer to today, it is understood that there are trends toward machine learning, blockchain, e-learning, GAI, and learning analytics, as well as AI.

## 3.3. Conceptual structure and thematic maps

In this part of the research, an attempt was made to determine the general view of the conceptual structure using *Multiple Correspondence Analysis (MCA)* based on the keywords determined by the authors for the research topic. Thanks to this analysis, conceptual mapping was tried to be determined in detail. Therefore, the conceptual structure of AI-containing documents has been visualized since 1981. Below are the MCA findings of scientific articles containing AI in education (Figure 19).

**Figure 19**

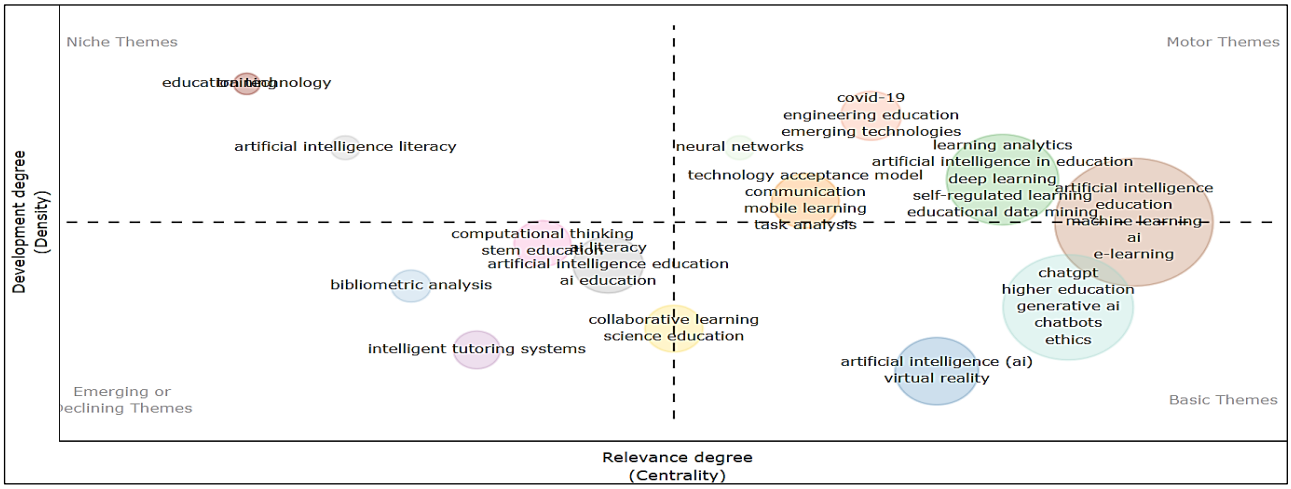
*AI in Educational Conceptual Structure Map (MCA Method)*




When Figure 19 is examined, according to the MCA result based on the keywords determined by the author(s) related to the research topic, the best dimension reduction was calculated as 48%, depending on three different clusters. According to the figure showing the factor analysis application, the clusters represented contain different colors, and the distance between the points represents common features (Wong et al., 2021). Accordingly, it can be seen that new generation technological concepts such as *"learning analytics," "AI," "ChatGPT," "higher education," "AI in education," "machine learning," "deep learning," "intelligent tutoring systems," "chatbots," "ethics," "GAI"* and *"language learning"* are more intense in the red cluster. Therefore, the effects of technological innovations are felt quite intensely in this cluster. In the blue cluster, more technology and education combinations such as *"education," "technology," "creativity,"* and *"learning"* come to the fore. In the green cluster, innovations in education such as *"educational innovation," "GAI,"* and *"academic integrity"* stand out. Below is the thematic map representing AI-related topics in education (Figure 20).

**Figure 20**

*AI in Educational Thematic Map (Authors Keywords)*




The clustering algorithm Walktrap style was preferred in visualizing the thematic mapping in Figure 20. The map has four quadrants: Niche, Engine, Emerging or Declining, and Basic themes. The bubble size in the image is determined in proportion to the number of keywords preferred by the authors and is interpreted depending on the bubble size (Mostofa, 2022). Motor themes, one of the four quadrants, involve high density and centrality and indicate internal and external development (Cobo et al., 2011).

The representations determined within this theme are the technology acceptance model, communication, mobile learning, task analysis, learning analytics, AI in education, deep learning, AI, education data mining, and self-regulated learning. These representational contents are widely used in the relevant field and cover a wide area of influence. Another quadrant, Niche themes, consists of developed but isolated representations. The representations determined within this theme are education technology and AI literacy. Although the impact areas of these representative contents are limited, they provide valuable information about the content of the study area. Another quadrant, Emerging or Declining themes, consists of low-density and central representations. The representations determined within this theme are as follows: computational thinking, stem education, AI education, bibliometric, and intelligent tutoring systems. Although the impact areas of these representational contents are limited, they represent the center of the study field. Another quadrant is basic themes; it involves low density but high centrality. The representations determined within this theme are as follows: e-learning, generative AI, chatbots, ChatGPT, and virtual reality. This theme also shows the prevalence of the field of study and provides information about the trends of today's AI-related studies.

## 4. Results, Discussion and Recommendations

Within the scope of this study, a bibliometric analysis of AI-related studies in the field of education from the past to the present was carried out. According to the determined criteria, it has been observed that the increase in the number of articles containing AI in the field of education has been continuous since 1981. It has been determined that the number of scientific articles and citations has gained momentum, especially in the last five years, and similar increases in AI are expected to increase in the coming years. These findings coincide with the results of studies conducted in previous years (Bozkurt et al., 2021; Chen et al., 2022; Peak & Kim, 2021). As AI took place in human history, the development of new technological tools that will profoundly affect social life has accelerated. Therefore, both the increase in the number of scientists and the diversity of AI-based applications indicate that AI will be an essential field of study in the future. Because of the increase in reference numbers, interest in AI is expected to increase. Especially considering that the development of other disciplines depends on education, the effects of AI on education will be inevitable. For this reason, depending on the number of scientific studies and citations in the future, documents related to AI in education will reach significant volumes. Similar studies indicate that the number of studies on AI will increase significantly in the coming years (Bahroun et al., 2023; Forero-Corba & Negre-Bennasar, 2024; Xie et al., 2019).

It has been determined that authors named Hwang, G. J, Chui, T. K. F., Chai, S. S., Gulson, K. N., Ogata, H., Su, J. H., Xie, H. R., and Zou, D. are more prominent in the field of AI in the field of education. These authors direct the developments in the field and lead in determining the content of the study subjects. These authors' common features include receiving many citations, designing qualified studies, and creating reference sources by creating content-rich resources in the field. When the most cited studies were examined, it was determined that the article "A Reference Model for Learning Analytics," published by Chatti et al. (2012), stands out. In this study, the authors focused on learning analytics, which includes many disciplines such as machine learning, AI, information retrieval, statistics, and visualization. Another highly cited study by Garcia et al. (2007) published "Evaluating Bayesian Networks' Precision for Detecting Students' Learning Styles." The authors used the proposed Bayesian model to determine the student's learning style in an AI web-based education system in this study. These studies are seen as pioneering studies in terms of the development and progress of AI. Considering the increasing role of AI in our lives, the need for such studies is expected to increase. In social development, AI-focused technological content is needed more than ever, and valuable steps are being taken to develop productive AI-based applications (OECD, 2019; UNESCO, 2021). For these reasons, AI systems, included in people's daily lives in all segments of society, will continue to become an indispensable part of life.

Another research finding was obtained from the distribution of responsible authors by country. Corresponding authors are mostly affiliated with China, the USA, the UK, Australia, Spain, and Korea. Therefore, there is intense interest in AI in education studies in these countries. On the other hand, many different countries are interested in this research topic. This finding parallels studies in the literature (Hinojo-Lucena et al., 2019). The majority of writers stand out as writers from a single country. These authors generally participate in joint studies based on geographical proximity and produce a limited number of studies in the context of multi-country authors. Especially in the period close to the present day, authors named Hwang, G., Chiu, T. K. F., and Chai, C. S. have taken the dominant role. These authors are also seen as core authors and profoundly influence change in the field. One of the remarkable findings of the research is that institutions in Hong Kong have come to the fore in AI-related studies in the field of education. Many influential authors are affiliated with these institutions (The Education University, The Chinese University, Hong Kong University) and collaborate intensively on published quality studies. Network analysis reveals the invisible collaborative network of countries and institutions participating in research through scientific collaboration visualization and helps intuitively display potential scientific collaborators (Chen et al., 2022). In the findings obtained from network analyses, authors named Hwang, Chen, Zawacki-Richter, Luckin, Williamson, Chiu, Openai, Dwivedi, Cotton, and Fryer determined that the connection clusters in the network visualization were thick and frequent. Therefore, these authors unite on similar subject contents and stand out more on the topics in their fields of study. The subject areas of these authors include content that will guide the field, such as AI application examples, the theoretical framework in AI-based learning, AI-based learning outcomes, AI-designed learning experiences, and the effectiveness of AI in application areas. In terms of resources, there is heavy collaboration traffic between Computer & Education, Computer Assisted Language Learning, Computers in Human Behavior, Educational Technology & Society, Journal of Computer Assisted Learning, British Journal of Educational Technology, International Journal of Educational Technology in Higher Education and Science Education, Journal of Research in Science Teaching, Journal of Science Education and Technology, Review of Educational Research and International Journal of AI in Education resources. These sources are prestigious and have gained a respected place around the world. Most of these sources, which contain qualified studies, have SSCI, SSCI-Expanded, and ESCI indexes and are scanned in the WoS database (WoSG, 2024). Another result of the research findings is that countries from many continents cooperate in the cooperation network. Especially China and the USA stand out in this field. Although this finding is expected, it is known that the Ministry of Education of China has intensive studies in AI (Cui et al., 2018; Huang et al., 2021b; Shi et al., 2024). Similarly, many publishing organizations are based in the USA and host leading studies in this field (OECD, 2019).

According to the findings obtained from the trending topic and thematic change heading of the research, it has been determined that as we get closer to the present day, ChatGPT, generative AI, machine learning, deep learning, blockchain, AI in ethics, language learning chatbots, intelligent tutoring systems and learning analytics topics become prominent. These issues are among the current issues in the field. AI has permeated many areas of our lives with the development of technology. It has become an essential part of our social lives. Therefore, the presence of AI in educational environments will be felt more and more day by day (Chen et al., 2020; Huang et al., 2021a; Hwang et al., 2020; Lin et al., 2021; Russell & Norvig, 2021). AI technology has emerged as a revolutionary force that has profoundly transformed various aspects of human life (Bahroun et al., 2023). The research findings show that AI is addressed in education in many ways. Developments resulting in the development and use of AI in education provide innovative opportunities for researchers to benefit from AI. Therefore, when the effects of AI in different subject disciplines are evaluated together, the subject diversity in the field will expand further. Such bibliometric studies provide valuable clues in determining trends, contents, productions, and collaborations in the field. Therefore, periodically reviewing publications related to the research topic is necessary.

### 4.1. Limitations and agenda and implications for future research

This study aims to examine the current landscape of AI in education, predict its future effects, and explore its future direction. Conducting longitudinal studies emphasizing curriculum designs to ensure the full integration of AI into educational environments can provide qualified data for future research. Its effects over long periods can be especially revealed with the help of longitudinal studies. The keywords presented by the researchers revealed a clear pattern regarding AI in education, which has yet to escape the field of traditional education. Therefore, in-depth research on the direct effects of AI algorithms and tools on education can be further encouraged. The emergence of AI technologies in education has begun to manifest itself intensively in areas such as medicine and health, engineering, economy, transportation, agriculture, and logistics. Therefore, its relationship with the field of education can be investigated by conducting similar studies in different disciplines. In particular, the impact of AI-based tools in learning environments can be examined through experimental research, and their role in shaping the future of education can be revealed in depth. The findings obtained from the research offer valuable opportunities for the integration of AI into education and the diversification of educational content. Considering the findings of studies involving AI, researchers can conduct studies on the effects of educational materials with more dynamic content by focusing on individual learning. More emphasis can be placed on subject areas that will shape the lifelong learning experience of AI applications. Additionally, learning designs can be created to increase AI awareness. Topics such as ChatGPT, machine learning, deep learning, and blockchain can be researched by considering many factors, such as students' achievements, interests, performances, perceptions, and affective changes. The effects of collaborative learning applications that center on the collaboration of humans and AI can be determined to achieve educational outcomes, which is another gap in the field. In addition, their effects on the performance of students with specific learning difficulties can also be examined. This study, which deals with the content of AI in education holistically, also has certain limitations. The most important limitations of the study include the fact that only the WoS database was used, Education Educational Research was chosen as the WoS category, only studies written in English were included in the research, and only scientific articles were used as the data set.

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