Studies on the use of Artificial Intelligence in teacher education

Cigdem HURSEN[1,4], Erinc ERCAG[2], Fezile OZDAMLI[3, 5]

[1] Curriculum and Instruction Department, Ataturk Faculty of Education,
Near East University, Nicosia

[2] Computer Education and Instructional Technology Department, Kyrenia University, Kyrenia

[3]Department of Innovation and Knowledge Management,
Near East University, Nicosia

[4] Educational Sciences Research Center, Ataturk Faculty of Education,
Near East University, Nicosia

[5] Computer Information Systems Research and Technology Center,
Near East University, Nicosia

cigdem.hursen@neu.edu.tr; erinc.ercag@kyrenia.edu.tr; fezile.ozdamli@neu.edu.tr

Abstract: *This study aimed to examine the studies using "artificial intelligence in teacher education". WoS database was preferred, and 143 documents were analysed. It was determined that the studies published between 2010 and July 2024 were popular in 2023 in terms of both density and total impact power. It was also determined that the researchers intensively preferred the article document type, and most of the studies were written in English. It was revealed that studies on using "artificial intelligence in teacher education" were intensively conducted in People's Republic of China and the USA, and the researchers with the highest citation power were "Chiu, Thomas" and "Chai, ching-sing". The keywords most frequently used by the researchers in their studies and with the highest total link strength are "artificial intelligence", "teacher education", "chatgpt", "education", "teacher training", "ethics", "higher education", "ai", "digital literacy", "assessment", "learning", "teaching", "pre-service teachers", "professional development", "technology", "generative ai", "k-12 education" and "machine learning".*

Keywords: Artificial Intelligence, Prospective Teachers, Teacher Training, AI., Bibliometric Analysis.

1. Introduction

The 1990s marked a significant milestone in the field of education with the introduction of intelligence tutoring systems (ITS), a pioneering application of artificial intelligence technologies. These systems, an extension of computer-assisted instruction, brought to light the potential of AI in education. The classic ITS model, comprising the domain model, the learner model, the instructional model, and the learning environment or user interface, showcased the varying degrees of intelligence across different ITS programs (Freedman, Syed & McRoy,

https://doi.org/10.58503/icvl-v19y202431

2000). According to Google Trends data, artificial intelligence has steadily gained interest, particularly since 2018. This surge in interest is not just a passing trend but a significant movement shaping the future.

In particular, artificial intelligence is making a significant impact in fields such as medicine, finance and industry (Goodell et al., 2021; Bahoo et al., 2024; Кубатко, Озімс & Вороненко, 2024; Weidener & Fischer, 2024), and education is no different from these fields (Salas-Pilco, Xiao & Hu, 2022). Ouyang and Jiao mentioned three different paradigms for using AI in education. In the first paradigm, AI is guided and utilised to guide cognitive learning. The second is AI-assisted; learners actively collaborate with AI. The third is AI-empowered; it allows learners to take ownership and agency in their learning experiences. As paradigms change, the role of the learner becomes more active (Ouyang & Jiao, 2021). Parallel to these, artificial intelligence, which is ahead of traditional approaches in education, promises a great change in the learning process. Artificial intelligence in education provides real-time feedback to learners, supports individual learning, and allows institutions to analyse learner data and decision-making processes easily.

In a project that emphasizes that 21st-century students live in the age of artificial intelligence, it is stated that learners should be trained as both conscious consumers and artificial intelligence designers. The project, which emphasizes the importance of students being competent enough to develop and apply artificial intelligence from an early age, emphasizes the importance of ethical issues and explains the necessity of providing students with information about artificial intelligence ethics. It is expected that not only students but also teachers have the knowledge and skills regarding artificial intelligence applications. It is extremely important for teachers to know and use artificial intelligence-supported technologies to facilitate teaching activities and to recognize and meet the needs of students. In order to ensure the integration of artificial intelligence applications in the classroom, it is deemed necessary for teachers to have technological, pedagogical, and content knowledge. In addition, not only information technology teachers but also teachers from different branches are expected to have these skills (https://facilitate-ai.eu, 2023).

In his study, Wang examined the advantages and challenges of the use of 5G and artificial intelligence technologies in English teaching. According to the results, it provides students access to a wide range of learning resources, an individualized learning experience, and an easy evaluation of the learning and teaching process. The difficulties that may be experienced during the process are stated as technological costs, privacy protection and network security. In parallel with the results obtained, Wang noted that more studies should be conducted on "artificial intelligence applications" in teacher education, and the creation of policies and standards should be encouraged (Wang, 2023). In this context, teacher education is also experiencing significant changes due to these digital transformations. Teacher education continues to evolve to include online education

and active learning that move beyond the traditional classroom. Additionally, with the increasing use of artificial intelligence technologies, changes are being made in teacher education. Easily analyzing the discourses of prospective teachers in online platforms is just one of these advantages (Salas-Pilco, Xiao & Hu, 2022).

Researchers note that AI applications collaborate seamlessly with educators and provide environments to foster hyper-personalized learning journeys, collaborative and project-based learning, and immersive experiences through augmented and virtual reality. In addition, the study states that there are many difficulties, including ethical concerns, digital participation and teacher training, and that "artificial intelligence applications" should be examined together with these problems, and solutions should be produced (Chaudhry & Goswami, 2024). Sun et al. investigated factors affecting prospective teachers' willingness to integrate artificial intelligence into teaching practices. These factors are first, TPACK, which refers to how preservice teachers integrate technology, pedagogical approaches, and content knowledge; Secondly, Perceived Usefulness, which expresses perceptions about the success of "artificial intelligence applications" in the learning process; third, perceptions of the ease of use of "artificial intelligence applications" in the learning process; and finally, pre-service teachers' self-confidence that they can use these technologies effectively (Sun et al., 2024). Similarly, the study conducted by Zhang et al. stated that the two main factors affecting prospective teachers' intentions to use artificial intelligence are their thoughts about how useful these technologies are and their perceptions about ease of use (Zhang et al., 2023).

Numerous studies in education have examined the application of AI technologies and student-teacher perspectives in light of AI. In their study, Zhang et al. stated that the use of "artificial intelligence applications" in education is increasing and that teacher candidates' attitudes and skills towards these technologies may potentially impact the learning outcomes of their future students (Zhang et al., 2023). So, this study aims to identify current research trends in "artificial intelligence applications" for teacher education. A bibliometric analysis was conducted in this context to find the most common research topics, emerging research fields, and major trends in the literature. This analysis is a vital first step in presenting the current state of research in this area and helping us better comprehend the implications of "artificial intelligence applications" in teacher education. As a result, educational partners will be better equipped to focus their future studies on this area. They will have a more thorough understanding of how artificial intelligence technologies are used in teacher education.

2. Methodology

The bibliometric analysis method was preferred to evaluate the use of "artificial intelligence in teacher education" systematically. Bibliometric analysis, which has a wide place in research as a scientific speciality, is considered an

important method used to search and analyse large volumes of scientific data (Ellegaard & Wallin, 2015; Donthu et al., 2021). This study was carried out to identify the studies involving the use of “artificial intelligence in teacher education”, to determine the development and trends, to shed light on the deficiencies and to guide the researchers, the researchers with the most studies and the most cited researchers in this field, the countries that produce the most publications, the keywords that will help researchers to form a conceptual structure in their studies and the sources with the most scientific studies are included.

2.1 Data collection

The bibliometric analysis data was obtained from the Web of Science (WoS) Core Collection database. WoS, the information and technology provider of the scientific research community, was chosen because it is a popular and rich database that serves researchers and research communities by hosting many high-impact journal articles, conference proceedings and books, including open-access journals.

During the investigation, the terms "Artificial Intelligence" OR "Machine Intelligence" were used to search the Web of Science database OR "AI" OR "Robotic Intelligence" OR "Intelligent Tutoring Systems" AND "Teacher Training" OR "Teacher Education" by choosing the topic option searching for article title, abstract, keywords and author keywords. All years, languages, document types and all document types were included in the search. In the query, 143 publications were reached. The data collection process ended on 22 July 2024.

2.2 Data analysis

The publications included in the study were mapped and interpreted with VOSviewer software (Van Eck & Waltman, 2010; VOSviewer, 2020). This study analysed the publications in the data set using “citation” and “co-occurrence” techniques. With citation analysis, it was aimed to determine the most cited authors, countries and sources that are effective in this field by conducting studies on the use of “artificial intelligence in teacher education”. In addition, the data set obtained was analysed by “co-occurrence” technique to determine the relationship between the keywords used by the authors in their articles. The distribution of the publications included in the study according to “publication years”, “countries”, “document types” and “languages” were calculated with percentage values.

2.3 Limitations of the study

The study is limited to the use of “artificial intelligence in teacher education” in terms of field. The study's data set was limited to the data obtained from the WoS database. The study was limited to the bibliometric analysis method, and the data were analysed with citation and co-occurrence analysis techniques. The search index of the study was limited to the terms "Artificial Intelligence, Machine Intelligence, AI, Robotic Intelligence, Intelligent Tutoring Systems, Teacher Training and Teacher Education".

3. Findings

The distribution of research on “artificial intelligence in teacher education” in the WoS database is tabulated and interpreted in this section based on publication years, nations, document kinds, and languages. Furthermore, citation and co-occurrence analysis approaches were employed to analyze and tabulate the publications included in the acquired data set.

3.1 Distribution of studies published between 2010-2024

3.1.1. Distribution of studies according to year of publication and citation time

The study's findings revealed that 143 publications on "the use of artificial intelligence in teacher education" were made in the WoS database between 2010 and 2024. Figure 1 shows the distribution of the studies in terms of years and citation times.

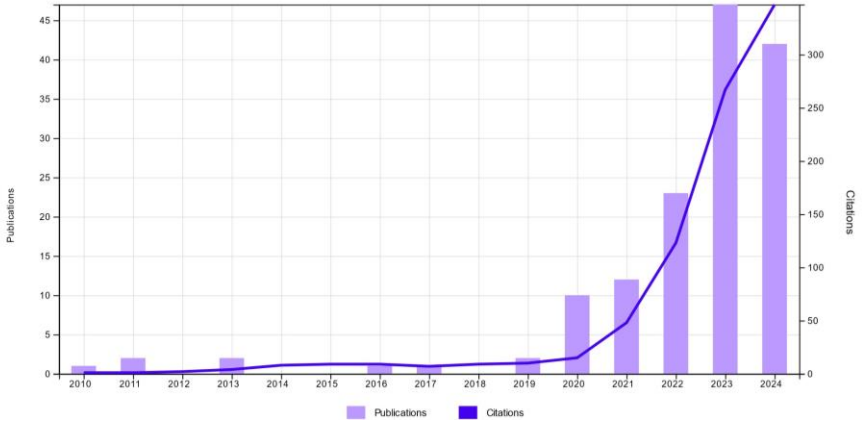

Figure 1. Distribution of the studies in terms of years
https://www.webofscience.com/

As seen in Figure 1, publications on using “artificial intelligence in teacher education” were first published in 2010 (n=1, 0.699%). Until 2020, it was seen that very few studies were carried out quantitatively on the use of “AI in teacher education”, while the studies increased significantly in 2020 (n=10, 6.993%) and continued to grow after 2020. From the findings obtained, it was revealed that the studies on the use of “AI in teacher education” were extremely popular in 2023 (n=42, 29.371%), and the highest number of publications was this year.

3.1.2 The breakdown of “research on artificial intelligence's application in teacher education by country”

The distribution of countries that attach importance to the use of “artificial intelligence in teacher education” and carry out studies in this field is given in Figure 2.

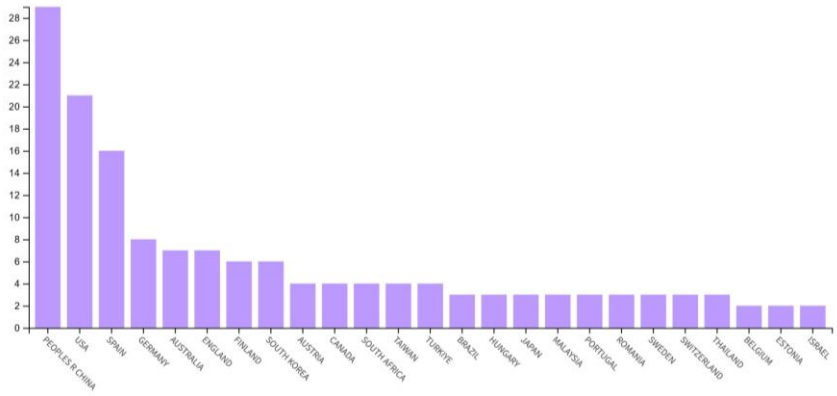

Figure 2. Distribution according to countries
https://www.webofscience.com/

It was determined that publications on using "artificial intelligence in teacher education" were carried out in People's Republic of China. The country where 29 publications were carried out includes 20.280% of the studies. 14.685% of the studies were conducted in the USA (n=21). Another country that attaches importance to using "AI in teacher education" and carries out studies in this direction is Spain, which has 16 publications in this field (11.189%). Another country with studies in the field is Germany with eight publications (5.594%). Apart from the mentioned countries, different countries have fewer publications in quantitative terms but carry out studies in the field. As shown in Figure 2, Belgium, Estonia, and Israel have the fewest studies in the field quantitatively.

3.1.3 Studies according to document types

Publications according to document types were analysed, and it was determined that 111 of them were articles (77.622%), 21 of the studies were Early Access (14.685%), 19 were Proceeding "Papers" (13.287%), and 10 were "Review Articles" (6.993%). The document types with quantitatively fewer studies were "Book Chapters" (n=4, 2.797%), "Editorial Material" (n=2, 1.399%), "Correction" (n=1, 0.699%) and "Data Paper" (n=1, 0.699%). One of the interesting findings was that two of the studies were "Retracted Publication" (n=2, 1.399%).

3.1.4 According to published languages

The distribution of the study according to the published languages is given in Table 1.

Table 1. Publication languages

	Record Count	%
Chinese	1	0.699
English	139	97.203
Spanish	3	2.098

According to the findings, most studies were published in English (n=139, 97.203%).

3.2 Citation and co-occurrence analyses of studies on the use of artificial intelligence in teacher education

Citation of the authors

Through an analysis of the authors' citation power, this study also sought to determine which scholars contributed most to “AI in teacher education”. The authors with the highest citation power are shown in Figure 3 with network visualisation. According to the citation analysis, a document can have up to 25 authors. An author could only have authored two papers at most. A minimum of one citation was required for each of the writers analyzed. 17 of the 411 writers fulfilled the thresholds within the parameters of the analysis (17 of the 411 authors meet the thresholds).

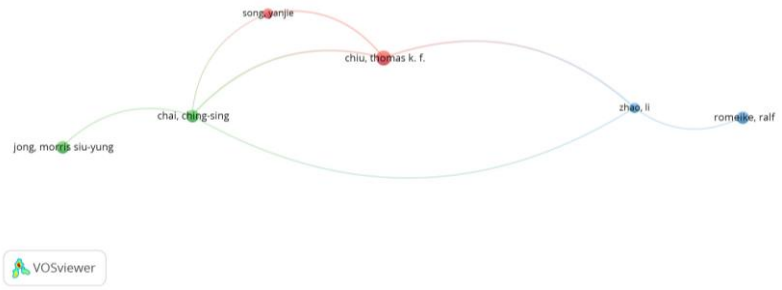

Figure 3. Network maps of authors with the highest citation power

The author with the highest citation power for using “artificial intelligence in teacher education” is "Chiu, Thomas" with four documents, 172 citations, and six total link strengths. The second author with the highest citation power for using “artificial intelligence in teacher education” is "Chai, Ching-Sing," with three documents, 148 citations, and five total link strengths.

Citation of the countries

The highest number of different countries per document was found to be 25, the lowest number of papers a country had to have was four, and the least number of citations a country could have was one in this study, which also examined into countries with strong citation power. It was determined that 12 out of 49 countries met the thresholds. Each of the 49 countries was given a total connection strength calculation for the study, and the nations with the highest total link strength were included. Items 6, cluster 3, link 7, and total link strength 10 were identified due to the analysis. The People's Republic of China had the highest citation power regarding the use of “AI in teacher education”. The analysis of the countries with high citation power according to years is given in Figure 4 with overlay visualisation.

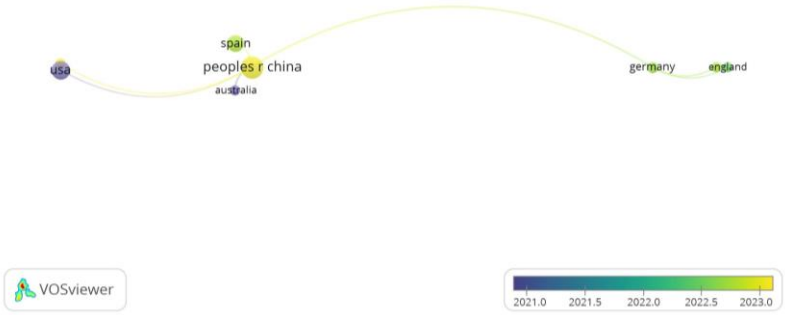

Figure 4. Time network map of countries with high citation power

As seen in Figure 4, the United States of America (The documents=21, The references=227, Total link strength=3), followed by the People's Republic of China, was found to have the highest citation strength among the countries with studies on the use of artificial intelligence in teacher education. Examining the citation power of the nations by year reveals that the majority of the research are conducted between 2021 and 2023. The United States of America held the title of top citation power in 2021, followed by Spain in 2022 and the People's Republic of China in 2023. Other countries with high citation power are Taiwan, Canada, Finland, Finland, Germany, England, Australia, South Africa, South Korea and Turkey.

Citation of the documents

Of the documents included in the study, 78 met the threshold. It was paid attention that each selected document had at least one citation. When the citation analysis was analysed according to the papers, seven items, three clusters and seven links were identified (Figure 5).

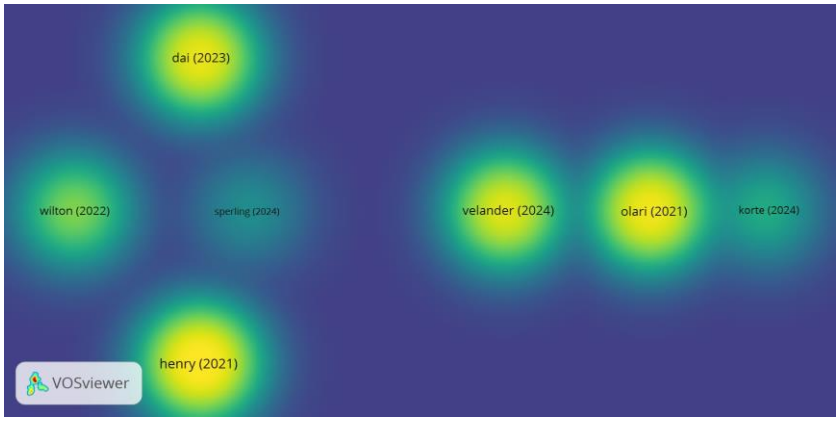

Figure 5. Density map of documents with high citation power

With document citation analysis, the documents with the highest citation power in the field are determined and researchers are provided with resources

about important works in this field. It is seen that Henry (2021), Dai (2023), Olari (2021), Valender (2024), Wilton (2022), Korte (2024) and Sperling (2024) are the documents with the highest link citation power according to the size of the clusters. It was determined that the papers with high connection strength were realised after 2020. In this context, studies on the use of "artificial intelligence in teacher education" have gained importance, especially in 2022.

Co-occurrence analysis of the author's keywords

The keywords used intensively by the researchers who conducted studies on using "artificial intelligence in teacher education" and their relationships with each other were determined using the co-occurrence analysis technique. A keyword's minimum number of occurrences was 3. 35 of 494 keywords met the threshold. In the study, the documents with the highest total link strength were selected and the keywords preferred by the researchers in these documents are given in Figure 6.

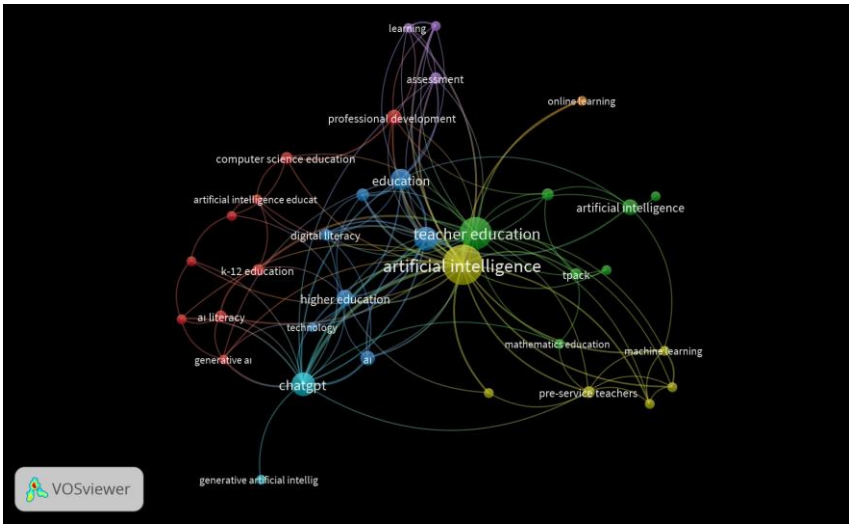

Figure 6. Co-occurrence of the authors' keywords

"Artificial intelligence" ("44 occurrences" and "82 total link strength") was found to be the most often used keyword by the researchers in their investigations. "Education" ("12 occurrences" and "29 total link strength"), "ChatGPT" ("15 occurrences" and "34 total link strength"), "teacher education" ("29 occurrences" and "49 total link strength"), "teacher training" ("16 occurrences" and "25 total link strength"), "ethics" ("5 occurrences" and "12 total link strength"), "higher education" ("8 occurrences" and "12 total link strength"), "AI" ("6 occurrences" and "11 total link strength"), and "digital literacy" ("4 occurrences" and "11 total link strength"). These are the other keywords most frequently used by researchers and have the highest total link strength.

4. Discussion and conclusion

A total of 143 studies published in the WOS database between 2010 and July 2024 were included in the study. The researchers searched using the keywords determined in all categories of the database. The results obtained from the research show that studies on the use of “artificial intelligence in teacher education” started in 2010, but the studies increased after 2020. After the COVID-19 pandemic, research on many online learning technologies has increased (Zhang et al., 2023) The year 2023 was determined to be the most popular year for studies on using “AI in teacher education”.

The country with the highest number of studies on using “artificial intelligence in teacher education” and the highest citation power was the People’s Republic of China and then the USA. It was also determined that the researchers preferred to conduct their studies mostly in article document type and English language. The author with the highest citation power for using “artificial intelligence in teacher education” was identified as "Chiu, Thomas K.F.". Another author who contributed the most to the field is "Chai, Ching-Sing". The documents with the highest link citation power were found to be by Henry (2021), Dai (2023), Olari (2021), Valender (2024), Wilton (2022), Korte (2024) and Sperling (2024). The keywords that the researchers preferred to use in their studies and had the highest total link strength were "artificial intelligence", "teacher education", "ChatGPT", "education", "teacher training", "ethics", "higher education", "AI", and "digital literacy".

It is recommended that researchers who will carry out studies on the use of “artificial intelligence in teacher education” in the future should direct their studies by considering the results obtained from this study. It is believed that the results obtained from the study will direct and guide the researchers' studies. Especially the documents, researchers, countries and keywords with high total link power will shed light on future research in this field.

REFERENCES

Bahoo, S., Cucculelli, M., Goga, X. & Mondolo, J. (2024) Artificial intelligence in Finance: a comprehensive review through bibliometric and content analysis. *SN Business & Economics*. 4 (2), 23. doi:10.1007/s43546-023-00618-x.

Chaudhry, M. & Goswami, N. (2024) Shaping tomorrow’s minds: The future of education in an AI (Artificial Intelligence)-augmented world. In: *Integrating Generative AI in Education to Achieve Sustainable Development Goals*. pp. 386–407. doi:10.4018/979-8-3693-2440-0.ch022.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N. & Lim, W.M. (2021) How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*. 133, 285–296. doi:10.1016/j.jbusres.2021.04.070.

Ellegaard, O. & Wallin, J.A. (2015) The bibliometric analysis of scholarly production: How great is the impact? *Scientometrics*. 105(3), 1809–1831. doi:10.1007/s11192-015-1645-z.

FACILITATE – AI: Guidelines for facilitating the learning of Artificial Intelligence (AI) by School Students of Grades 7-12. (2023). https://facilitate-ai.eu [Accessed 25 September 2024].

Freedman, R., Syed, A. & McRoy, S. (2000) What is an intelligent tutoring system? *Portal: The ACM Digital Library*. 11 (3), 15–16.

Goodell, J.W., Kumar, S., Lim, W.M. & Pattnaik, D. (2021) Artificial intelligence and machine learning in finance: Identifying foundations, themes, and research clusters from bibliometric analysis. *Journal of Behavioral and Experimental Finance*. 32, 100577. doi:10.1016/j.jbef.2021.100577.

Кубатко, О., Озімс, С. & Вороненко, В. (2024) Influence of Artificial Intelligence on Business Decision-Making. *Mechanism of an economic regulation*. (1 (103)), 17–23. doi:10.32782/mer.2024.103.03.

Ouyang, F. & Jiao, P. (2021) Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence*. 2, 100020. doi:10.1016/j.caeai.2021.100020.

Salas-Pilco, S., Xiao, K. & Hu, X. (2022) Artificial Intelligence and Learning Analytics in Teacher Education: A Systematic Review. *Education Sciences*. 12 (8), 569. doi:10.3390/educsci12080569.

Sun, F., Tian, P., Sun, D., Fan, Y. & Yang, Y. (2024) Pre-service teachers' inclination to integrate AI into STEM education: Analysis of influencing factors. *British Journal of Educational Technology*. doi:10.1111/bjet.13469.

Van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84*(2), 523–538.

VOSviewer - Visualizing scientific landscapes (2020). https://www.vosviewer.com [Accessed 2 April 2021].

Wang, H. (2023) The application of "5G+AI" information technology in college English teaching. In: *Proceedings of the 2023 International Conference on Information Education and Artificial Intelligence*. 22 December 2023 New York, NY, USA, ACM. pp. 888–893. doi:10.1145/3660043.3660200.

Weidener, L. & Fischer, M. (2024) Artificial Intelligence in Medicine: Cross-Sectional Study Among Medical Students on Application, Education, and Ethical Aspects. *JMIR Medical Education*. 10, e51247. doi:10.2196/51247.

Zhang, C., Schießl, J., Plößl, L., Hofmann, F. & Gläser-Zikuda, M. (2023) Acceptance of artificial intelligence among pre-service teachers: a multigroup analysis. *International Journal of Educational Technology in Higher Education*. 20 (1), 49. doi:10.1186/s41239-023-00420-7.