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The Impact of AI on Education: A Dual Approach of Systematic Review and Bibliometric Mapping

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Abstract

This study aims to analyze the development of literature on Artificial Intelligence Education through a systematic review and bibliometric mapping approach. The method used involves screening articles from the Scopus database with the keywords "artificial intelligence AND education", resulting in 111 selected articles. The analysis was carried out using the PRISMA protocol and VOSviewer visualization to identify publication trends, geographical distribution, institutional affiliation, and keyword relevance. The results showed a significant increase in the number of publications over the past decade, with contributions from China, South Korea, and the United States dominating. Higher education institutions in Finland and Hong Kong were also recorded as active in publications. Frequently emerging topics include AI literacy, curriculum design, the role of teachers and students, and computational thinking. This study found that Artificial Intelligence Education not only includes learning about AI, but also the use of AI as a learning tool. The conclusion of this study emphasizes that the integration of AI in education is a systemic transformation that requires a multidisciplinary approach, competency-based learning, and strong ethical policies to support the development of inclusive and adaptive 21st century education.

Keywords: *Artificial Intelligence Education, Bibliometric Analysis, Curriculum Design, Systematic Review, Technology Integration*

1. Introduction

The increasing importance of discussing Artificial Intelligence (AI) education today lies in its transformative role in reshaping the educational landscape and preparing learners for an AI-driven future. Historically, pioneers like Seymour Papert laid the foundation for integrating computational thinking into education, emphasizing the potential of intelligent systems in enhancing learning [1]. As the Fourth Industrial Revolution introduces cyber-physical systems and automation, it becomes imperative for education systems to adapt accordingly. AI offers personalized learning, adaptive assessments, and intelligent tutoring systems that cater to diverse learner needs, fostering improved engagement and academic performance. Furthermore, open educational platforms such as MOOCs expand access to AI education globally, promoting equity in lifelong learning [2]. Despite its potential, several challenges remain especially regarding the preparedness of educators, who often lack sufficient AI literacy, particularly in developing countries. Ethical considerations, such as algorithmic bias and data privacy, also require careful navigation [3]. On a policy level, countries are actively integrating AI into national curricula, as seen in India's AI roadmap and South Korea's data science initiatives. Future directions involve the development of AI-driven pedagogical models, such as smart physical education systems and individualized learning platforms, which have shown positive outcomes [4]. To ensure relevance in this rapidly evolving landscape, continuous innovation and critical engagement with AI tools are essential for both educators and students. In essence, integrating AI into education is not only about technological enhancement but also about redefining learning for the 21st century through ethical, accessible, and learner-centered approaches [5].

The urgency of discussing Artificial Intelligence (AI) education today stems from its profound potential to reshape learning, workforce preparedness, and ethical engagement in the digital age. Historically, educational theorists like Seymour Papert laid the groundwork for computational thinking and constructivist learning approaches, which now underpin contemporary AI integration in classrooms [6]. As societies move deeper into the Fourth Industrial Revolution, characterized by cyber-physical systems and intelligent automation, AI education becomes a strategic necessity for equipping students with the competencies needed to navigate increasingly complex labor markets [7].

AI has already demonstrated its transformative power in improving educational delivery. Through technologies such as intelligent tutoring systems, adaptive assessments, and personalized learning platforms, students now receive more tailored and engaging learning experiences. These innovations have expanded educational access and improved comprehension, particularly in disciplines like science and

mathematics. Massive Open Online Courses (MOOCs) further democratize AI learning, making essential concepts such as machine learning, ethics, and algorithmic processes available to global learners regardless of geography [8]. However, several challenges must be addressed to ensure AI education fulfills its promise [9]. Many educators, particularly in developing nations, lack sufficient AI literacy and professional development opportunities, creating a significant barrier to effective classroom integration. Without proper training, educators may struggle to guide students through AI concepts, leading to shallow understanding or overreliance on automated tools. Furthermore, there are growing ethical concerns regarding data privacy, algorithmic bias, and the erosion of student agency and innovative thinking, especially when AI systems are deployed without adequate human oversight or inclusive policy frameworks. Globally, some governments have begun implementing proactive AI education policies. For example, South Korea has incorporated data science and AI into its national curriculum, emphasizing real-world applications and student-centered programming tasks. Similarly, India has proposed national strategies to integrate AI into public education, signaling the global shift toward systematized AI learning. These efforts highlight the need for coherent policy development, inter-sectoral collaboration, and adequate investment in teacher training. Equally important are the ethical frameworks that underpin responsible AI education [10]. Scholars emphasize the need to teach concepts such as transparency, accountability, fairness, autonomy, and inclusivity as part of any AI curriculum. These frameworks not only help mitigate the risks of bias and privacy breaches but also cultivate a generation of learners capable of critically engaging with AI systems. Regular audits and stakeholder education are essential to maintain accountability and align AI use with educational values [11]. Ultimately, AI education plays a pivotal role in preparing learners for an unpredictable and rapidly evolving future. It fosters the development of problem-solving, critical thinking, and digital fluency skills increasingly demanded by the global workforce. With thoughtful integration, ongoing educator support, and strong ethical oversight, AI can transform classrooms into inclusive, dynamic, and future-ready environments. Therefore, prioritizing the discourse around AI in education today is not only timely but essential for cultivating resilient and competent future citizens [12].

2. Literature Review

Artificial Intelligence Education refers to the integration of AI technologies into educational processes, focusing on the development of knowledge and skills necessary for the effective use and application of AI in various fields. This includes the training of students in AI-related subjects, the creation of specialized degree programs, and the adaptation of existing curricula to incorporate AI content, particularly in Information Technologies and Computer Sciences. Artificial Intelligence Education refers to the integration of artificial intelligence (AI) within educational contexts, focusing on how AI technologies can enhance teaching and learning processes [13]. This includes the examination of AI's role in educational design and its implications for academic instruction, as highlighted by the analysis of keywords such as "artificial intelligence," "education," and "technology" in the research paper [14]. The study emphasizes the importance of AI in educational settings, indicating that it not only influences educational methodologies but also shapes the future of educational program design through AI-powered interventions [15]. Artificial Intelligence Education is defined in terms of cognitive science, where it emphasizes the materialization of metaphysical thinking to create intelligent machines. This approach aims to enhance students' thinking processes by clarifying their cognitive processes. The field of AI education is currently evolving, with global efforts to determine "what and how to teach students" in the context of AI. This includes initiatives like the Artificial Intelligence for K-12 Standards (AI4K12), which proposes five big ideas for AI education. Additionally, AI education can be categorized into "Learning with AI" and "Learning about AI," focusing on both the content taught and the methods of teaching. Artificial Intelligence Education is defined as the process of teaching and learning about artificial intelligence, which is increasingly important in today's technology-driven world [16]. It encompasses the development of curricula that focus on specific competencies and hands-on training with real-world problems, enabling learners to acquire the necessary skills to become successful AI practitioners. The research highlights the need for a competency-based approach in AI education, which aligns with innovative pedagogical principles and addresses the requirements of both educational institutions and the job market.

Table 1: Defining elements of intelligence (AI) within educational

No.	Defining elements of intelligence (AI) within educational	References
1.	Artificial Intelligence Education refers to the integration of AI technologies into educational processes, focusing on the development of knowledge and skills necessary for the effective use and application of AI in various fields.	[17]
2.	Artificial Intelligence Education refers to the integration of artificial intelligence (AI) within educational contexts, focusing on how AI technologies can enhance teaching and learning processes.	[18]
3.	Artificial Intelligence Education is defined in terms of cognitive science, where it emphasizes the materialization of metaphysical thinking to create intelligent machines.	[19]
4.	Artificial Intelligence Education is defined as the process of teaching and learning about artificial intelligence, which is increasingly important in today's technology-driven world.	[20]
5.	Artificial Intelligence Education is defined as the process of educating individuals, particularly children, about artificial intelligence (AI) concepts, capabilities, and their implications in society	[21]

Findings from several studies on Artificial Intelligence Education show that this field is developing in response to the global need for the integration of artificial intelligence technology in educational contexts. Based on conceptual analysis and data visualization, Artificial Intelligence Education does not only refer to the teaching of AI-based content, but also includes the use of AI technology in designing, managing, and adapting the learning process [22]. This study highlights the importance of developing curricula and study programs that are specifically designed to equip learners with relevant knowledge and skills in the digital era, especially in the fields of Information Technology and Computer Science. In addition, AI in education is seen as a pedagogical approach that integrates cognitive principles, where technology is used to enhance students' thinking and learning processes. Global initiatives such as AI4K12 reflect systematic efforts to determine "what" and "how" AI should be taught at various levels of education. Furthermore, the concepts of Learning with AI and Learning about AI describe two main focuses in AI educational practices: one as a learning aid and the other as the object of learning itself. The emphasis on competency-based learning also emerged as a key strategy to bridge the gap between education and industry demands, suggesting that AI education must be applicable, interdisciplinary, and responsive to technological developments and job market needs. These findings confirm that Artificial Intelligence Education is not just a technological trend, but a fundamental transformation in the design and implementation of 21st century education [23].

3. Method and analysis

A systematic literature review employing a bibliometric approach quantitatively assesses literature to discern trends, patterns, and key research entities within a discipline. Using frameworks such as PRISMA, this approach ensures a comprehensive and replicable literature examination, providing a clear and transparent picture of the topic being studied. The inclusion criteria established were: (1) articles published up until May 25, 2025, (2) publications in English, and (3) focusing on the topic of artificial intelligence AND education. Bibliometric analysis was performed using VOSviewer, visualizing bibliographic data to analyze citation networks, author collaborations, and co-occurring keywords, revealing the intellectual structure and dynamics of the research field. The combination of bibliometric analysis and systematic review helps researchers synthesize empirical findings and map the landscape of research activity, including identifying key contributors and emerging trends. The integration of both approaches provides a comprehensive understanding of the development, historical flow, and future direction of the research field, making it highly beneficial in interdisciplinary studies for gaining deeper insights. Bibliometric analysis is also used for strategic purposes in scholarly publication, introduced by Bertrand et al. (1970) to evaluate scientific journals based on their economic weight [24].

The preliminary phase in this scholarly examination involves the selection of keywords, which can be accomplished through a macro methodology (top-down), progressing from expansive search trajectories to more narrowly defined studies and topics. Consequently, after evaluating the limitations inherent in prior research and the scarcity of studies addressing artificial intelligence AND education, this investigation incorporates the keyword " artificial intelligence AND education as a focal point within the article's title, abstract, and keyword sections. Furthermore, the Scopus database is employed by researchers for a myriad of investigational purposes, including the execution of literature reviews, identifying subject-matter experts, and monitoring research trends.

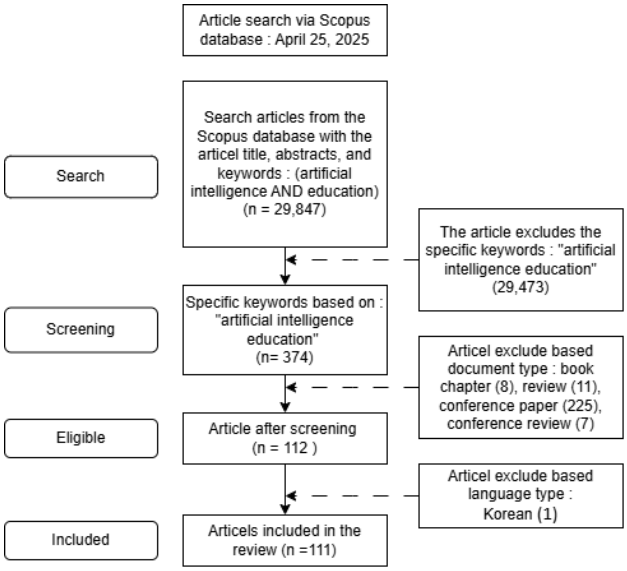

Fig. 1: Stages of PRISMA

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart in Figure 1 illustrates the process of searching and selecting articles for a systematic review conducted through the Scopus database on April 25, 2025. In the initial search stage (Search), articles were searched based on the title, abstract, and keywords "artificial intelligence AND education", which resulted in 29,847 articles. Furthermore, in the initial screening stage (Screening), 29,473 articles were excluded because they did not contain the specific keyword "artificial intelligence education", leaving 374 relevant articles. The next stage is further screening to ensure the eligibility of the articles (Eligible). At this stage, exclusion was carried out based on the type of document, namely book chapters (8), review articles (11), conference papers (225), and conference reviews (7), which resulted in 262 articles being eliminated. After this screening, 112 articles remained. Then, one additional article was excluded because it was written in Korean, leaving 111 final articles included in the systematic review (Included). Overall, this diagram illustrates the systematic and step-by-step selection process in determining the most relevant articles that meet the criteria for analysis in a scientific review of artificial intelligence in education. This document is then further analyzed in this study to answer RQ1: What is the trend of scientific publications related to artificial intelligence education over the last decade? RQ2: What is the distribution of research investigations related to artificial intelligence education in terms of focus areas, educational levels, and geographic coverage? RQ3: What are the theoretical and practical implications of the existing research on artificial intelligence education from the perspective of future research directions?

4. Result and Discussion

The results of this study focus on findings from 111 articles in the Scopus database on artificial intelligence education. This data is sourced from identifying the number of articles published, publications throughout the years, and journal sources. This study will also highlight the most influential elements in artificial intelligence education, including the authors, affiliations, and the countries involved.

RQ1: What is the trend of scientific publications related to artificial intelligence education over the last decade?

The trend of scientific publications shown in the "Documents by Year" diagram shows significant developments in research related to artificial intelligence education during the period 2015 to 2024. In general, this diagram shows a very sharp growth, especially since 2020. In the early period, namely 2015 to 2019, the number of publications was very low and stagnant, with only 1 to 2 documents per year, even

in 2018 and 2019 there were no publications at all. This indicates that this topic was not yet a major focus of attention in the scientific community at that time. However, starting in 2020, there was a significant spike with the publication of 4 documents, then increasing drastically to around 15 documents in 2021. This positive trend continues with the number of publications as many as 20 documents in 2022 and 28 documents in 2023. The most striking increase occurred in 2024, with a total of 45 publications marking the highest point in the last decade. The surge indicates the growing interest of academics and practitioners in the integration of artificial intelligence in education. Most likely, this is driven by the rapid advancement of AI technology, the need for technology-based learning innovation, and the shift in global education paradigms following the COVID-19 pandemic. Thus, this diagram not only illustrates the quantitative growth in scientific literature but also reflects the shift in research priorities towards developing smarter and more adaptive education systems.

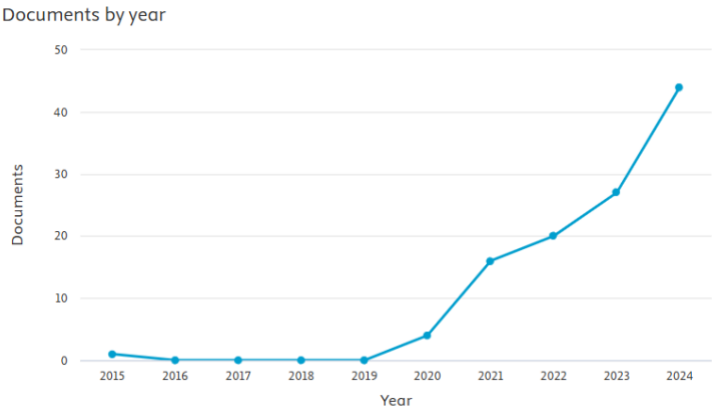

Fig. 2: Trend of Scientific Publications Related To Artificial Intelligence Education

RQ2: What is the distribution of research investigations related to artificial intelligence education in terms of focus areas, educational levels, and geographic coverage?
The distribution of scientific publications by country or territory shown in the "Documents by country or territory" diagram shows global involvement in research on artificial intelligence education. This data reflects that this topic is not only a local concern, but has become a strategic issue at the international level. The country that is most dominant in producing scientific publications in this field is China, with the highest number of documents, which is around 31 documents. This position confirms China's active role as a center for the development and application of artificial intelligence technology in their education system. In second place is South Korea with around 25 documents, followed by the United States with 17 documents. Both countries have consistently shown a strong commitment to technology-based educational innovation, especially in the use of AI for adaptive learning, recommendation systems, and personalization of education. Hong Kong is in fourth place with around 10 documents, indicating the active role of this region as part of the global research network under Chinese influence.

European countries such as Finland, the United Kingdom, Germany, and Spain, also contributed in more moderate numbers, ranging from 3 to 7 documents. This reflects a more selective and in-depth approach in exploring the pedagogical and ethical aspects of the use of AI in education. On the other hand, Taiwan, South Africa, and several other countries are also involved although in relatively smaller numbers, indicating that the discourse on artificial intelligence education has reached various geographical and social contexts. From this data, it can be concluded that China, South Korea, and the United States are the main players in the development of artificial intelligence education literature, with significant support from several other developed countries. This finding also reflects the global direction in integrating AI into the education system, with a diverse focus ranging from learning efficiency, educational data analysis, to the development of future-oriented intelligent learning systems.

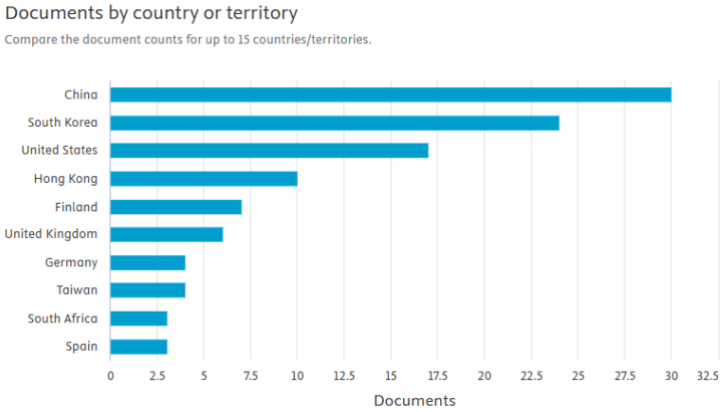

Fig. 3: Distribution of Research Investigations Related To Artificial Intelligence Education

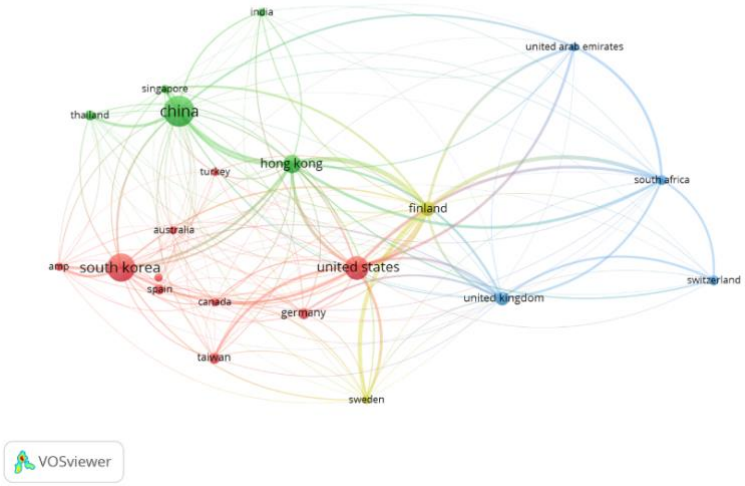

Fig. 4: Network Country visualization

This visualization of collaboration between countries in research on artificial intelligence education displayed through a network map from VOSviewer reveals a tight and dynamic global network structure. Each circle represents a country, while the size of the circle indicates the number of publications or the strength of the country's involvement in international cooperation. The lines connecting countries indicate collaborative relationships in scientific publications, where the thickness of the lines reflects the strength of the collaboration. From this visualization, China appears to be the strongest and most extensive center of collaboration, as seen from the dominant node size and the number of connection lines to various other countries such as Singapore, India, Thailand, and Hong Kong. This shows that China is not only quantitatively productive, but also actively building international cooperation, especially with countries in the Asian region. Hong Kong, although geographically small, has a strategic role in building connectivity between China and various other countries, including Finland and the United States.

South Korea and the United States form a very strong collaboration network group, especially with countries such as Germany, Canada, Spain, and Taiwan. This shows that collaboration is not only limited to the Asian region, but also includes partners from Europe and North America. On the other hand, Finland appears to be an important hub within the group of European countries, building significant networks with the UK, Sweden, and several Asian countries such as India and Hong Kong. Other groups that also appear active are countries such as the United Arab Emirates, South Africa, and Switzerland, which, although not dominant in the number of publications, show involvement in international collaborations, especially with European and Asian countries. This pattern shows that the issue of artificial intelligence education is cross-border and requires cross-disciplinary and cross-cultural contributions. Thus, this collaboration map emphasizes the importance of a collaborative approach in developing AI research in education. International collaboration not only enriches the perspectives and contexts of AI application, but also accelerates the diffusion of knowledge and best practices between countries in facing the challenges and opportunities of AI-based educational transformation.

The distribution of publications based on institutions or affiliations involved in research on artificial intelligence education shows that there are a number of academic institutions that have made significant contributions to the development of scientific literature in this field. The data displayed in the “Documents by affiliation” diagram shows that Itä-Suomen yliopisto (University of Eastern Finland) is in the top position with the largest number of publications, namely 7 documents. This shows that Finland, through this institution, has a special attention to the development of artificial intelligence-based education, which is in line with its position as a country with high quality education in the world. In the next position, there are three institutions from the Hong Kong region, namely the Chinese University of Hong Kong, The University of Hong Kong, and The Education University of Hong Kong, each contributing 6 to 3 documents. The dominance of institutions from Hong Kong shows that this region is one of the leading research centers in the field of AI in education. This may be due to a combination of strong technological infrastructure support, international orientation, and progressive education policies in the application of digital technology. Several universities from other Asian regions are also active, such as South China Normal University, Central China Normal University, and National Taiwan Normal University, each of which contributed 3 papers. The presence of these institutions underscores the important role of higher education institutions in East Asia in encouraging the exploration of AI technologies for pedagogical, evaluative, and administrative purposes in the education system. In addition, institutions from the United States such as Willamette University also appear on the list, demonstrating the involvement of American universities in cross-disciplinary research on the integration of AI in learning. Meanwhile, Jyväskylän ammattikorkeakoulu (Jyväskylä University of Applied Sciences) and Kongju National University complete the list as representatives from Finland and South Korea, indicating the representation of regional and vocational education institutions that are actively involved in this research area. Overall, this data indicates that research on artificial intelligence education is not only concentrated in top global universities, but also involves a variety of educational institutions from various geographic regions. This reflects that the issue of AI integration in education has become a broad concern that spans various education systems, both in developed and developing countries, and encourages cross-country and cross-institutional collaboration.

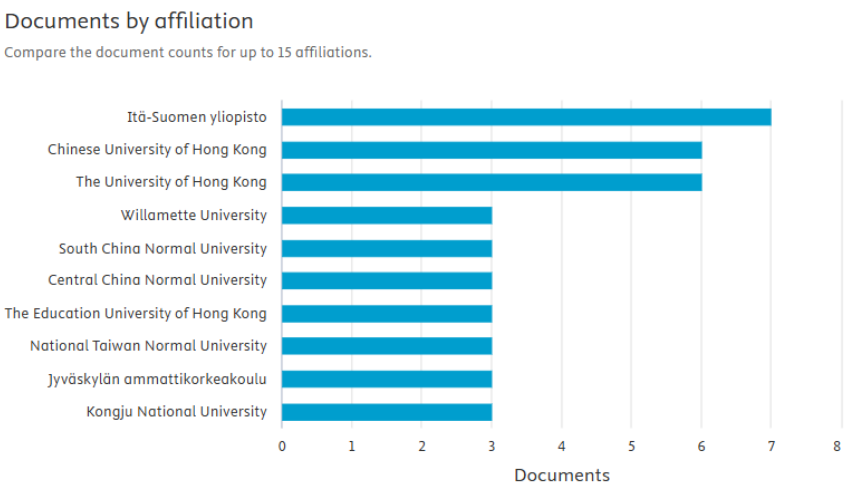

Fig. 5: Top Institutions Contributing

The distribution of publications based on journal sources shows the dynamics of the spread of artificial intelligence education studies across various academic channels. Based on the "Documents per year by source" data, it appears that there are five main journals that consistently publish articles in this field, with an increasing trend in recent years. One of the most prominent journals is Education and Information Technologies, which in 2024 recorded the highest number of publications, namely 6 documents. This sharp spike indicates that the journal is the main reference for researchers exploring the integration of artificial intelligence in the context of education. Meanwhile, the journal Computers and Education: Artificial Intelligence also showed a significant increasing trend, especially in 2024 with a total of 4 documents. This increase indicates that this journal, which specifically focuses on the issues of education and artificial intelligence, is increasingly in demand and is becoming a place for publication that is relevant to the topic. The consistency of publication of articles in this journal from 2021 to 2024 shows its important role in facilitating the dissemination of new knowledge in this field. The IEEE Access journal, known as a multidisciplinary journal with a broad coverage of technology, also plays an important role, although with a relatively stable trend since 2015. The number of published documents ranges from 1 to 2 per year, without a major spike. This indicates that although it is not a journal that focuses specifically on education, IEEE Access remains a platform used by researchers who combine technical approaches to AI with educational aspects. In addition, the journal Sustainability (Switzerland) and the International Journal on Advanced Science, Engineering and Information Technology also contribute, although in limited numbers. Sustainability, for example, indicates the relationship between the topic of AI and education with the issue of sustainability, which is a global concern. Meanwhile, engineering journals such as the International Journal on Advanced Science, Engineering and Information Technology open up opportunities for cross-disciplinary approaches in this study.

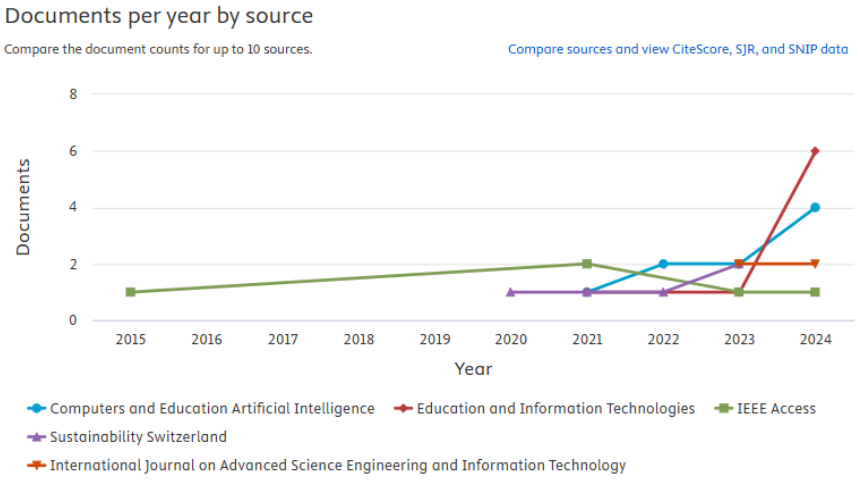

Fig. 6: Documents per year by source

Overall, this trend shows that publications on artificial intelligence education are not only limited to technology education journals, but have also spread to multidisciplinary and sustainability-oriented journals. This reflects that this topic has developed into a strategic issue that touches various scientific domains and has become a priority on the global research agenda.

RQ3: What are the theoretical and practical implications of the existing research on artificial intelligence education from the perspective of future research directions?

The visualization of keyword co-occurrence in research on artificial intelligence education reveals a complex and interconnected intellectual map, reflecting the broad and interdisciplinary spectrum of topics in this field. The main keyword at the center of the network is “artificial intelligence education”, which is closely linked to concepts such as AI literacy, machine learning, curriculum design, students, teachers, and computational thinking. The size and proximity of the nodes reflect the intensity of the relationship between one concept and another, where the larger and more connected a node is, the more important the position of the concept in academic discourse. The red cluster in the visualization illustrates the focus on AI literacy and early childhood education, higher education, and AI literacy. This shows great attention to the mastery of the basics of AI by students from an early age, which is the foundation for the comprehensive integration of AI technology into the educational curriculum. The green cluster highlights the role of students and teachers in the AI-based learning process. Large nodes such as “students” and “learning systems” show that the majority of studies emphasize how students receive and interact with AI-based learning systems, and how teachers as facilitators utilize this technology in the learning context. Meanwhile, the yellow group emphasizes aspects of curriculum design and pedagogy. Nodes such as curriculum design, education, and teaching show that the challenges in implementing AI in education lie not only in technology, but also in how AI can be systematically included in the teaching process, including changes in curriculum structure and evaluation methods. The blue and purple groups containing keywords such as computational thinking, motivation, engineering education, and computer-aided instruction indicate a multidisciplinary approach, where AI is not only considered as a tool, but also as a separate learning domain that intersects with computer science, engineering, and educational psychology.

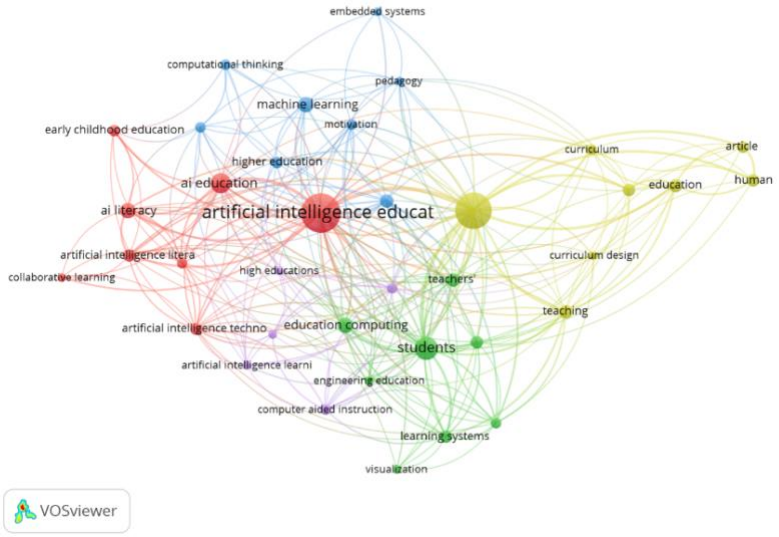

Fig. 7: Network Country visualization

Overall, this map shows that research in the field of artificial intelligence education is growing rapidly and covers various important aspects of education, from individual learning, the role of educators, curriculum design, to implementation challenges at various levels of education. The emphasis on AI literacy, the role of students, and data-based pedagogical approaches show that the integration of AI in education is not just a technological issue, but a comprehensive transformation of the global education system.

5. Conclusion

This study presents a comprehensive mapping of the research landscape of Artificial Intelligence Education through a combination of systematic review and bibliometric approaches, which yields important findings on the global direction, intensity, and focus of this field. The main novelty of this study lies in the combination of bibliographic data visualization techniques and thematic analysis to identify dominant elements such as AI literacy, the roles of students and teachers, and adaptive curriculum design. A remarkable finding of this study is the revelation of the dominance of China, South Korea, and the United States in related scientific publications, as well as significant contributions from educational institutions in Finland and Hong Kong, which demonstrate the dynamics of cross-country and regional collaboration. In addition, conceptual classifications such as learning with AI and learning about AI enrich the understanding of emerging new pedagogical approaches. This study also emphasizes the importance of integrating ethical values, competency-based approaches, and adaptive educational policy responses to technological advances. Thus, this paper not only strengthens the knowledge base on AI in education but also provides strategic directions for the development of future educational research and policies that are more inclusive, collaborative, and future-oriented.

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