ARTIFICIAL INTELLIGENCE IN EDUCATION AS A WAY TO CONSTRUCT EDUCATIONAL CONTENT: BIBLIOMETRIC ANALYSIS

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Abstract. This study presents a comprehensive bibliometric analysis of international scientific publications devoted to the application of artificial intelligence (AI) in the development and adaptation of educational content over the period 2014-2024. Over the last decade, AI has evolved from an auxiliary technological instrument into a strategic driver of educational transformation, enabling the transition from episodic digital solutions to complex, integrated systems such as intelligent tutoring platforms, adaptive learning environments, and generative AI models capable of producing textual, visual, and multimedia educational resources. Against this backdrop, the study aims to systematize the rapidly expanding body of academic research and to identify key trends, conceptual clusters, and geographical patterns that shape contemporary scientific discourse on AI in education. Based on data retrieved from the Scopus database, the research examines publication dynamics, productivity and impact of leading journals, authors, and institutions, as well as international collaboration networks. Special attention is given to thematic areas related to generative AI, personalized and adaptive learning, sustainable education, and the pedagogical implications of AI integration, including technology acceptance and behavioral aspects of learners and educators. The findings reveal a pronounced growth in publication activity since 2021, indicating the formation of a consolidated and interdisciplinary research field. Overall, the results confirm that AI is increasingly perceived not merely as a tool for automation, but as a foundational resource for designing innovative, personalized, and sustainable educational ecosystems.

Keywords: bibliometric analysis, artificial intelligence in education, generative AI, educational content, digital transformation of education, sustainable education.

Introduction

Over the past decade artificial intelligence (hereinafter referred to as AI) has evolved from an auxiliary tool into a strategic resource that transforms the educational sphere. The complex solutions have taken the place of the episodic use: from intellectual tutors and adaptive platforms to generative models capable of generating educational texts, visual materials, test assignments and multimedia scenarios. Studies have demonstrated that modern systems, like ChatGPT, effectively generate substantive and structured responses to standard academic queries. For instance, the analysis of responses to pedagogical field students found out its ability to formulate clear and supportive explanations encompassing both theoretical and applied aspects of learning [1]. In this regard, AI is being considered more frequently as a driver in the paradigm shift in education, presenting new possibilities and creating complex challenges [2]. Within this context, research aimed at studying the relationship of the academic staff to AI tools integration into educational practice acquires particular significance [3]. However, the majority of this research is focused on expansion of knowledge base on the use of AI ensuring sustainable education advancement, identification of best practices on its integration and introducing academic staff to the potential advantages of this technology [4]. For the analysis of effectiveness of such implementations it is essential to capture not only empirical results, but also theoretical models such as Technology Acceptance Model (TAM), which enable the evaluation of key factors, influencing users' perceptions of technological tool [5].

The relevance of this aim becomes evident in the context of adaptive learning, where AI integration highlights the urgent need for an automated identification of students' individual learning styles. Unlike traditional methods of diagnosis (questionnaire, tests), which suffer from subjectivity and low involvement, automated approaches imply an objective and dynamic analysis. This highlights a significant research gap, requiring an evaluation of effectiveness and practical application algorithms of automated identification of style of learning in educational environment [6].

This gap becomes urgent and acute in the context of narrow and sensitive areas of education, such as special education. This visually demonstrates a systematic review aimed at analyzing the latest research trends in the application of AI for the need of special education. The analysis of 29 research publications from 2008 to 2020 revealed that most research focused on the development of cognitive and affective skills. The majority of these studies were conducted in schools and were primarily aimed at supporting pupils with various forms of disabilities, particularly autism spectrum disorders [7]. At the same time, the implementation of AI technologies and related digital practices lays the foundation for fundamentally new forms of educational interactions. One of such promising areas is pedagogically supported crowdsourcing, which allows involving students to a joint creation of educational content, thereby improving their teaching experience to the new quality level. The key challenge, however, remains understudied behavioral patterns of students in the frame of this process, known as «educational search» [8].

In the present context AI integration into the educational practice plays a pivotal role, as AI-technologies have the potential to eliminate the existing gap in the analysis and support of students' behavioral strategies. For a comprehensive examination of this potential a systematic literature review was conducted in the Science Direct, Taylor & Francis and Emerald Insight databases whose publications are officially cited in the Scopus scientometric database. The purpose of the study is to identify the dynamics of publication activity on the topic of the use of artificial intelligence in education, the analysis of productivity, subject area and impact in the field of artificial intelligence research in education, geographical and substantive analysis in this area.

Review results demonstrate that AI-based instruments such as chatbots and intelligent tutoring systems make a significant contribution for the advancement of adaptive learning, enhancing both the efficiency of pedagogical activity and the students` academic performance. It should be noted that that AI use extends beyond automation of routine tasks; it provides the basis for the establishment of a flexible, personalized educational environment. Therefore, AI integration for teachers' support represents not merely a technological upgrade, but a strategic step in the evolution of pedagogical practices enabling improved effectiveness in covering various learning formats such as crowd sourcing and maximizes their educational impact [9].

In accordance with the aim of the study 5 research questions have been identified:

RQ1 (Bibliometric analysis): What has been the publication activity trend on the topic of AI integration in education during the last decade (2014-2024).

RQ2 (Productivity analysis and impact): Which journals, authors and scientific organizations demonstrate the highest productivity and influence in the domain of AI research in education?

RQ3 (Subject area analysis and key topics): What are the main subject areas, scientific topics and conceptual clusters that define the contemporary scientific discourse in the field of AI in education?

RQ4 (Geographical analysis): What are the geographic characteristics and patterns of international collaborations in AI research within the field of education?

RQ5 (Content analysis and modelling): Which international approaches and collaborations in the field of AI application are most relevant for the tasks of automated generation and adaptation of educational content?

Thus, the conducted research is based on the analysis of the fact that in the period from 2014 to 2024, an independent scientific direction of artificial intelligence for the design of educational content was formed. The hypothesis focuses on the development of artificial intelligence for the development of educational content as an independent scientific field, which is reflected in publication activity, increased scientific impact indicators, expanded international research collaboration, and research consolidation. The theoretical significance of the study is aimed at systematizing scientific ideas about the role of AI in the educational process and identifying patterns of its development. The practical significance is revealed by the possibility of using the obtained results to construct adaptive courses and develop a strategy for implementing AI in the activities of educational organizations.

Materials and methods

The current study is based on a bibliometric analysis aimed at exploring the structure, dynamics and content of international scholarly publications dedicated to the challenges of AI implementation in education process, as well as construction and adaptation of substantive material based on AI tools. The study was conducted in stages, including a search strategy and definition of publication selection criteria. Inclusion methods covered timeframe (2014-2024), research subject area (Social Science), document type (article), and keywords reflecting the research topic. The next step was collecting and exporting bibliometric data, checking it and excluding irrelevant records in accordance with the specified search parameters. The third stage was aimed at a quantitative analysis of publication activity, which included determining the dynamics of the number of publications, distribution by sources, authors and organizations, as well as calculating scientific impact indicators. The fourth stage reflected the analysis of the geographical distribution of international scientific collaboration. At the fifth stage, an interpretation of the thematic structure of the publication was carried out based on the analysis of keywords and research clusters to identify the main direction of scientific discourse. Ultimately, at the final stage, the results were summarized and conclusions were formulated for the field of study.

For this study, Scopus (Elsevier, Netherlands) was selected as the main database, as it encompasses a wide range of peer-reviewed sources in the field of social and educational sciences and serves as one of the leading tools for conducting bibliometric analysis. The search strategy included a set of keywords, relevant to the field of study. The selection of key terms was scientifically justified based on the analysis of existing literature and the thesaurus database to ensure comprehensive coverage of relevant publications: (TITLE-ABS-KEY (artificial intelligence AND education) AND TITLE-ABS-KEY (educational content)) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA, "SOCI")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (EXACTKEYWORD , "Higher Education") OR LIMIT-TO (EXACTKEYWORD, "Students") OR LIMIT-TO (EXACTKEYWORD, "Artificial Intelligence") OR LIMIT-TO (EXACTKEYWORD, "Chatgpt") OR LIMIT-TO (EXACTKEYWORD, "Education") OR LIMIT-TO (EXACTKEYWORD, "Generative Artificial Intelligence") OR LIMIT-TO (EXACTKEYWORD, "Ai") OR LIMIT-TO (EXACTKEYWORD, "Teaching") OR LIMIT-TO (EXACTKEYWORD, "Learning")) AND (LIMIT-TO (OA , "all")).

The dataset, processed using the SciVal (Elsevier, Netherlands) tool integrated into the Scopus database, was subjected to a comprehensive bibliometric analysis for processing and visualization, data visualization was performed through software Microsoft Excel 365 (Microsoft Corp., USA).

As part of the study, statistical processing was carried out taking into account the following aspects were examined: dynamics of publishing activity, showing a sustainable growth in number of scientific papers and indicating the increase in academic interest in AI application and digital technologies in education; ranking of the leading scientific journals, authors and academic centers, defining strategic directions of the development in this area; geographic distribution of publication activity, that highlighted the countries with the most intensive research activity in the sphere of educational AI and digital transformation; a network analysis of co-authorship that identified clusters of international and interdisciplinary collaboration and indicating the emergence of sustainable scientific community; as well as an analysis of keywords enabled the identification of key research trends, including adaptive learning, personalization of education process, application of generative AI, the development of learning analytics tools and digital ecosystems. The conducted analysis described the current state and perspective research directions, defining the primary areas of development in academic discussions in this topic.

Results and discussion

The analysis of dynamics of publishing activity in the field of AI in education from 2014 to 2024 revealed a consistent upward trend of scholarly interest in this issue. In the early phase (2014–2020) the level of publishing activity remained low, limited to only a few articles per year (Figure 1). Quantitative dynamics characterizes the transition of research from the stage of formation to the stage of institutionalization. This type of research demonstrates sustained

scientific interest and reflects the problem. The observed intensification of publication activity in 2021 correlates with technological breakthroughs in the field of artificial intelligence.

The year 2021 marked a turning point, after which a gradual increase in scientific papers has been observed. A significant increase appeared in 2022, the growth rate acquired a multiplicative character: while fewer than ten publications were recorded in 2021, their number exceeded twenty by 2023. A sharp increase was observed in 2024, with article production reaching 75, suggesting a shift toward an exponential growth trajectory. Such indicators reflect not only a quantitative expansion, but also a qualitative strengthening, which is confirmed by an increase in the citation rate and scientific impact of the publication.

This picture allows to ascertain the evolution from fragmented and episodic studies toward the formation of a consolidated scientific field. The growth in publication activity is determined, on the one hand by advances in the field of generative AI systems (such as ChatGPT and other transformer architectures), and on the other by articulation of the problem of adaptive and sustainable education, personalization of learning process and the ethical implications of AI implementation.

Thus, the results of the study confirm the hypothesis concerning the emergence of a new, independent field of scientific inquiry over the past decade. Within its framework, AI is viewed not merely from an instrumental perspective, but as a strategic source for designing educational content and developing innovative educational ecosystems.
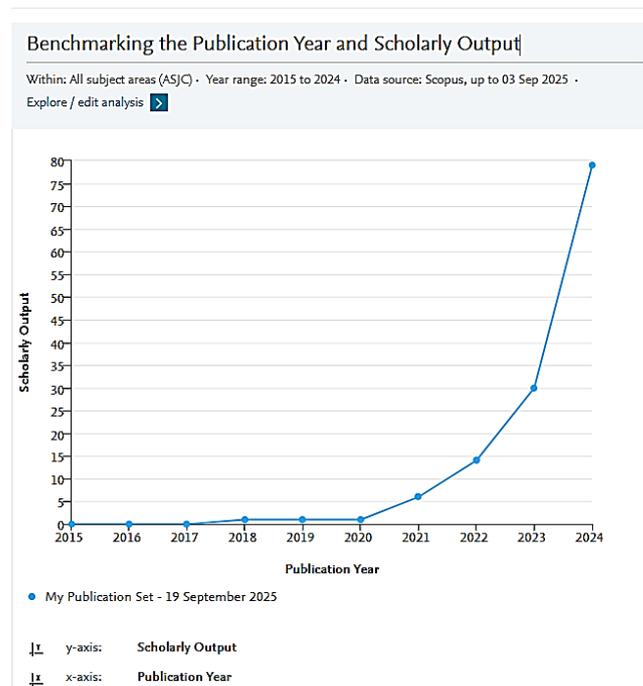

Figure 1 – The dynamics of publication activity growth in the filed of AI from 2014 to 2024

The analysis of sources taken from the Scopus database makes it possible to identify the key trends in the publication activity in the field of AI implementation in education. The results demonstrate not only the growth in publication quantity, but also their significant influence on the scientific community. The journal Sustainability (Switzerland) ranks first in terms of the number of publications (Scholarly Output) with 13 articles (Table 1). However, the other journals demonstrate the most significant levels of scholarly influence. The Journal of University Teaching and Learning Practice, despite only 2 articles possesses an exceptionally high Field-Weighted Citation Impact (FWCI) equal to 42,71, as well as a considerable number of citations (438). It indicates exceptionally high demand and impact of even individual studies in this field within the framework of this publication. Similarly, the journal Education Sciences with 4 publications shows a high FWCI (23,64)

and a large number of citations (533). The Computers and Education: Artificial Intelligence journal`s exceptional indicators in FWCI (12,76) confirms its status of a leading specialized source that combines significant amount of publications (9) with its high quality and impact.

Measuring absolute indicators of publication activity and scientific impact allows us to identify differences between the quantitative presence of sources in the research field and their actual contribution to science. This approach allows for a more objective assessment of the significance of scientific publications.

Table 1 – The leading scientific journals on the topic AI in Education (2014–2024)

№	Scopus Source	Scholarly Output	Views Count	Field-Weighted Citation Impact	Citation Count
1	Sustainability (Switzerland)	13	2476	7,21	857
2	Computers and Education: Artificial Intelligence	9	2185	12,76	817
3	JMIR Medical Education	8	462	9	249
4	BMC Medical Education	7	1050	7,66	165
5	International Journal of Emerging Technologies in Learning	6	690	2,73	134
6	Electronic Journal of e-Learning	5	953	9,92	347
7	Education Sciences	4	1315	23,64	533
8	Educational Process: International Journal	3	410	2,43	29
9	Frontiers in Education	3	304	8,47	99
10	International Journal of Information and Education Technology	3	432	1,65	106
11	Open Praxis	3	235	8,18	67
12	American Journal of Pharmaceutical Education	2	87	2,18	7
13	Formacion Universitaria	2	1037	1,77	15
14	Interactive Technology and Smart Education	2	280	7,38	37
15	International Journal of Learning, Teaching and Educational Research	2	403	3,05	24
16	Journal of Science Education and Technology	2	106	5,97	37
17	Journal of University Teaching and Learning Practice	2	924	42,71	438
18	Online Learning Journal	2	118	2,62	17

The results of the analysis suggest that studies concerning the implementation of AI in education are not only growing actively in terms of quantity, but also demonstrate a high degree of scientific impact, especially in specialized and professional journals. The distribution of publications across a wide range of disciplinary fields confirms the integrated nature of this scientific field, which lies at the intersection of technology, pedagogy and specific subject areas.

The analysis of publications by country distribution was organized using normalized scientometric indicators; this result made it possible to compare the scientific impact of studies regardless of differences in the volume of publication activity. The findings regarding the most productive authors enable the identification of key researchers and research teams that define the

development of AI topic in education. The results indicate the formation of an international research community with a significant concentration of scientific influence around specific scholars (Figure 2). The highest level of publication activity is demonstrated by Ilić M., Kuleto V. и Martins O.M.D. (with 3 publications), whose works received considerable attention from the scientific community (804 views) and high citation rates (410). Of particular note is a group of researchers, including Michel-Villarreal R., Salinas-Navarro D.E. и Vilalta-Perdomo E.L., who despite having a relatively small number of publications (2 works), demonstrate exceptional high scientific impact indicators (FWCI = 45,13) and citations (464). Similarly notable achievements are evident in Perkins M. (FWCI = 45,18, 455 citations).

Geographical analysis of author affiliations confirms the global character of research with the participation of scholars from Portugal, the United Kingdom, Mexico, Colombia, Vietnam, Israel, and other countries. A significant variability of metrics of scholarly influence is observed: whereas some researchers demonstrate moderate FWCI indicators (6,67 by the group Ilić/Kuleto/Martins), and other authors exhibit exceptionally high metrics (Acosta-Vargas P. - 21,55).

A distinctive feature of scientific landscape is the presence of international collaborations which are evidenced by the overlapping metrics of authors from various countries and institutions. The predominance of collective research over individual one confirms the interdisciplinary and cooperative nature of contemporary science in this field.

	Author	Affiliation	Scholarly Output	Views Count	Field-Weighted Citation Impact	Citation Count
1.	Ilić, Valentin Kuleto Milena	University Business Academy in Novi Sad	3	804	6.67	410
2.	Kuleto, Valentin	Information Technology School	3	804	6.67	410
3.	Martins, Oliva M.D.	PRT Polytechnic Institute of Bragança	3	804	6.67	410
4.	Blonder, Ron	ISR Weizmann Institute of Science	2	136	1.36	8
5.	Bucea-Manea-Țoniș, Radu	ROU Hyperion University	2	375	3.64	117
6.	Bucea-Manea-Țoniș, Rocsana	National University of Physical Education and Sports	2	375	3.64	117
7.	Feldman-Maggor, Yael	ISR Weizmann Institute of Science	2	136	1.36	8
8.	Michel-Villarreal, Rosario	GBR University of Leeds	2	931	45.13	464
9.	Ojeda, Adelaida D.	COL Universidad del Atlántico	2	1,037	1.77	15
10.	Perkins, Mike	VNM British University Vietnam	2	982	45.18	455
11.	Ranković, Marko	Univerzitet Union Nikola Tesla	2	594	7.78	328
12.	Salinas-Navarro, David Ernesto	MEX Universidad Panamericana (UP)	2	931	45.13	464
13.	Solano-Barliza, Andrés D.	COL Universidad de la Guajira	2	1,037	1.77	15
14.	Vilalta-Perdomo, Eliseo L.	GBR Aston University	2	931	45.13	464
15.	Aarón Gonzálvez, Marlyn A.	COL Universidad de la Guajira	1	365	1.20	3
16.	Abu-Zanona, Marwan	SAU King Faisal University	1	108	6.56	56
17.	Acosta-Vargas, Patricia	ECU Universidad de las Américas - Ecuador	1	404	21.55	184

Figure 2 – The leading authors working in the research topic

Thus, the study confirms the formation of productive international scientific teams that combine publication activity with high scientific impact which contributes to integration of AI research in education into the global scientific discourse.

An analysis of the geographical distribution of publication activity in the field of AI in education indicates the formation of polycentric structure of the global scientific community. Conducted research enables the identification of key national scientific centers and differentiates their contribution based on productivity indicators and research impact (Figure 3). The United States of America is the leader in terms of scientific output (23 publications), which at the same time exhibit consistent indicators of impact (FWCI = 9,8) and citations (854), confirming their systematic role toward advancing this field of study. China holds the second position by the number of publications (13), accompanied by considerable attention from the scientific community (1334 views) and by the absolute number of citations (465).

The position of the United Kingdom merits particular attention, which, with a relatively moderate number of publications (12) demonstrates the highest values of filed-weighted citation impact (FWCI = 18,52) and total number of citations (1309) reflecting a strong presence of fundamental and methodologically significant research.

Alongside the traditional centres of scientific production, there is an observable new scientific cluster development, exhibiting outstanding quality metrics. Mexico (5 publications, FWCI = 18,57), New Zealand (4 publications, FWCI = 18,33) achieve the highest relative indicators of scientific impact. Countries in the Middle East region, in particular Saudi Arabia (7 publications, FWCI = 16,18) and United Arab Emirates (6 publications, FWCI = 12,97) effectively combine the growth of publication activity with high scholarly impact. India`s indicators (4 publications, FWCI = 14,43) also confirms the trend toward the formation of research excellence centres beyond the traditional English-speaking world. Geographical scope of research is characterized by significant diversification, including European countries (Germany, Spain, Switzerland, Portugal), Asian (Turkey, Japan, South Korea, Malaysia), Latin America (Brazil and Mexico) and Oceania (New Zealand). The observed disparity between the volume of publication and their impact reflect various national strategies of science development from extensive growth in publication volume toward a focus on research quality and effectiveness.

	Countries/Regions	Scholarly Output	Views Count	Field-Weighted Citation Impact	Citation Count
1.	United States	23	2,110	9.80	854
2.	China	13	1,334	7.31	465
3.	United Kingdom	12	2,524	18.52	1,309
4.	Spain	8	1,301	8.42	308
5.	Canada	7	637	10.97	240
6.	Germany	7	844	10.06	241
7.	Saudi Arabia	7	1,672	16.18	837
8.	Turkey	6	769	6.31	149
9.	United Arab Emirates	6	1,055	12.97	345
10.	Mexico	5	1,237	18.57	477
11.	Portugal	5	1,288	11.85	549
12.	Sweden	5	483	4.59	74
13.	India	4	750	14.43	536
14.	Japan	4	252	3.54	45
15.	Malaysia	4	241	1.83	42
16.	New Zealand	4	489	18.33	213
17.	South Korea	4	662	8.36	120
18.	Brazil	3	311	9.28	103
19.	Colombia	3	1,247	6.31	66
20.	Indonesia	3	318	1.77	12

Figure 3 – Country/region, leading in the number of publication

Thus, a modern scientific ecosystem in the field of AI in education is characterized by a transition from a monocentric to a polycentric model, where alongside historically established scientific centres, new poles of scientific excellence are being formed, making a significant contribution to the development of this interdisciplinary area.

Indicators of scientific collaboration in the field of AI in education reveal substantial characteristics of cooperation models. The findings enable the formulation of specific conclusions (Figure 4). In the field of geographical collaboration, a significance predominance of international scientific initiatives is observed. Publications, prepared within the framework of international collaborations (33,3% of total array) demonstrate maximum quantitative and qualitative performance indicators. Notably, the level of work citation, created by international teams (104,6 citations per publication), is statistically comparable to the corresponding indicator of individual publications.

Field-Weighted Citation Impact meaning for an international collaboration (14,32) significantly exceeds the corresponding indicators of national (4,10) and institutional (5,59) frameworks of cooperation. Of particular scientific interest is a significant elevated metric of publication impact of prepared without co-authorship (FWCI = 14,32), which fully aligns with the standards of international collaborations. This fact may indicate the sustained significance of the roles of individual research strategies and the existence of independent scientific schools capable of generating research complying the international quality standards.

In the context of academic-corporate engagement, there is a complete absence of relevant publications (0%), indicating a significant misbalance between the academic and entrepreneurial sectors.

Collaboration metrics

Geographical Collaboration ⓘ

International, national and institutional collaboration by My Publication Set - 19 September 2025 in the selected year range.

Metric	Publication share	Scholarly Output	Citations	Citations per Publication	Field-Weighted Citation Impact
▪ International collaboration	33.3%	18	1,882	104.6	14.32
▪ Only national collaboration	24.1%	13	408	31.4	4.10
▪ Only institutional collaboration	20.4%	11	539	49.0	5.59
▪ Single authorship (no collaboration)	22.2%	12	1,272	106.0	14.32

Academic-Corporate Collaboration ⓘ

Academic-corporate collaboration by My Publication Set - 19 September 2025 in the selected year range.

Metric	Publication share	Scholarly Output	Citations	Citations per Publication	Field-Weighted Citation Impact
▪ Academic-corporate collaboration	0.0%	0	0	0.0	-
▫ No academic-corporate collaboration	100.0%	54	4,101	75.9	10.08

Figure 4 – Joint research collaborations between researchers

The high importance of FWCI within the international collaboration results in the high effectiveness of international scientific interaction and its role in accelerating the dissemination of knowledge. The results obtained highlight the need for the development of targeted programmes aimed at fostering academic-corporate partnership while maintaining support of international scientific collaborations as a key factor for science development in the field of AI in education.

The results obtained indicate the structural design of this subject area and its shift from fragmented studies to the stage of consolidation of scientific community. Defined trends may be used as an analytical base for critical evaluation of existing educational strategies and for adjustment of the national education development programme. Study results confirm the appropriateness of systematic integration of AI technologies in education process. Such integration can contribute to enhancing education quality content, personalized learning pathways and strengthening of competitive positions of national education system in the international context. A promising direction for further research appears to be the study of effectiveness of specific AI solutions in different educational areas and the development of assessment methodologies of their educational effectiveness.

RQ1 Dynamics of publication activity (2014-2024).

An analysis of publication activity over the period revealed a steady trend of growing scientific interest in the application of AI technologies in education. The need for empirical research to understand the user experience and perception provides insight that can guide future research aimed at understanding the significance of ChatGPT and similar AI systems in higher education [9]. Research on the integration of generative AI into adaptive learning systems reveals a range of advantages and problematic aspects of this technological integration. In terms of educational outcomes, there have been significant improvements, including increased academic performance, accelerated development of subject competencies, and increased student engagement through the personalization of educational content and adaptation to individual learning trajectories. However, the successful implementation of these advantages is hamperred by a number of systemic challenges that require an interdisciplinary approach to their solution [10].

The analysis of publication activity for the period identified a steady growth of scientific interest to AI technology application in education. The necessity of empirical research for understanding of experience and users perception provide insight into what may serve as a guiding framework for future research on understanding of meaning of ChatGPT and similar AI systems in higher education [9]. Research into generative AI integration to adaptive systems of learning reveals a complex of advantages and problematic aspects of this technological integration. Educational outcomes have demonstrated marked enhancement, characterized by improved academic performance, expedited acquisition of subject-specific competencies, and heightened learner engagement driven by personalizing educational content and the adaptation of learning process to individual learning pathways. However, a successful realization of these advantages is hindered by a number of systemic challenges, necessitating an interdisciplinary approach to their solution [10].

RQ2 (Productivity analysis and impact): Which journals, authors and scientific organizations demonstrate the highest productivity and influence in the domain of AI research in education?

The results of conducted bibliometric analysis indicate a concentration of the most significant publications addressing issues application of AI in education within specialized scientific journals focused on digital transformation and pedagogical innovations. Among the most productive sources are «Sustainability» (Switzerland), «Computers and Education: Artificial Intelligence», «International Journal of Emerging Technologies in Learning and Education Sciences». The dominant position of these journals within the research landscape is attributed to their capacity to consolidate interdisciplinary studies that integrate technological and pedagogical dimensions. Citation metric analysis reveals that such comprehensive works exert the most significant scholarly impact in this field. This supports the argument that further advancement in research necessitates a deeper synthesis of technological and pedagogical approaches. The reviewed studies highlight that university educators actively incorporate AI technologies into both research and teaching practices, utilizing them to explain AI principles, extract analytical insights, and facilitate students' experimental engagement with relevant tools. Of particular importance is the use of AI-based instruments in research processes, including linguistic translation and analytical data processing [11].

RQ3 (Subject area analysis and key topics): What are the main subject areas, scientific topics and conceptual clusters that define the contemporary scientific discourse in the field of AI in education?

Modern scientific discourse in the field of AI in education is defined by the integration of multiple disciplinary domains, forming an interdisciplinary research field. The leading positions are taken by pedagogy and educational science, computer science, engineering and social sciences which reflects a commitment to integrating the technological capabilities of artificial intelligence with educational practices and the broader social context.

At the level of research topics and conceptual clusters, particular attention is devoted to four key areas [12]. The first pertains to generative AI and the creation of educational content, including automated generation of assignments, adaptive texts, and multimedia materials. The second area focuses on adaptive learning and personalization, where core challenges involve identifying learning styles, analyzing student behavior, and configuring educational trajectories using machine learning algorithms. The third area addresses ethical and social dimensions, encompassing issues of authorship, academic integrity, equitable access, and inclusion. The fourth area encompasses sustainable education and digital transformation, wherein AI is regarded as a strategic resource for enhancing the efficiency, accessibility, and scalability of educational systems.

RQ4 (Geographical analysis): What are the geographic characteristics and patterns of international collaborations in AI research within the field of education?

Conducted geographical analysis of publication activity revealed a polycentric structure within the research domain in the sphere of AI in education. The highest concentration of scholarly output is located within three key centres: the United States of America, the United Kingdom and China. Notably, each of these three centres demonstrates a distinct model of scientific leadership. The United States and China are characterized by extensive model with a predominance of quantitative indicators (the publication volume, total citation count), whereas the United Kingdom demonstrates an intensive model with a highest indicators of relative research impact (Field-Weighted Citation Impact).

Thus, a modern scientific ecosystem is characterized by a transition from a monocentric to a polycentric model, where traditional scientific centres coexist with new growth poles. This transformation creates favorable conditions for the development of international scientific networks and cross-cultural exchange of knowledge, while simultaneously demanding solving the issues of commercialization and practical implementation of scientific results.

RQ5 (Content analysis and modelling): Which international approaches and collaborations in the field of AI application are most relevant for the tasks of automated generation and adaptation of educational content?

Modern international initiatives in the field of AI in education focused on the creation of intellectual systems capable of automatically generate and adapt education content.

These approaches are based on a combination of three key elements: generative models for creating materials, adaptive algorithms for personalising them, and uniform standards for ensuring the compatibility of solutions. In practice, the implementation of these approaches includes several areas of content generation, where large language models (LLMs) and RAG architectures are employed, to combine general knowledge with datasets of individual educational institutions. Personalized learning, which is achieved through methods such as Item Response Theory [13], Knowledge Tracing [14] and other algorithms of machine learning, which dynamically adapt the difficulty, and order of assignments to the needs of each student. These technological developments reach highest level of effectiveness within international collaborations involving universities, scientific centres and IT-companies. Collaborative work enables the development of shared sets of data, validation protocols and ethical standards, ultimately enhancing the quality, and reliance to digital educational products. In practice, the implementation of these approaches includes several areas of content generation, where large language models (LLMs) and RAG architectures are employed to combine general knowledge with datasets of individual educational institutions [15].

Conclusion

The conducted bibliometric analysis comprehensively characterized contemporary trends and research dynamics of AI application for construction of education content during the period from 2014 to 2024. Research results indicate a transformation of this scientific field from disparate publications to sustainable growth and consolidation stage that confirms its formation as independent field of scholarly inquiry.

The study revealed an exponential growth of publication activity in recent years, driven by the development of generative models of ChatGPT type and by updating personalized learning objectives. During the analysis the main scientific journals, authors and research centres were identified, constituting the core of this research field, a transition to a polycentric model of international collaboration involving active engagement of new research clusters was also documented.

The content analysis demonstrated an interdisciplinary nature of research, integrating pedagogical, technical, and social aspects. Among the key areas, the following stand out: the application of generative AI for the development of educational content, adaptive learning technologies and personalization.

Identified patterns and trends form the basis for further critical reflection on the role of AI in education. The results might be employed to refine the education strategies and the development of national initiatives, including enhancement of digital school transformation projects in Kazakhstan.

Prospective areas for further study include the assessment of pedagogical effectiveness of specific AI tools, development of methodologies of their integration into educational process and the expansion of international collaboration for the formation of sustainable educational ecosystems.

Financing information

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БІЛІМ БЕРУДЕГІ ЖАСАНДЫ ИНТЕЛЛЕКТ БІЛІМ БЕРУ МАЗМҰНЫН ҚҰРУ ТӘСІЛІ РЕТІНДЕ: БИБЛИОМЕТРИЯЛЫҚ ТАЛДАУ

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Аңдатпа. Бұл зерттеуде 2014-2024 жылдар кезеңінде білім беру мазмұнын әзірлеу және бейімдеу кезінде жасанды интеллектті (ЖИ) қолдануға арналған халықаралық ғылыми жарияланымдарға жан-жақты библиометриялық талдау ұсынылған. Соңғы онжылдықта жасанды интеллект көмекші технологиялық құралдан білім беруді қайта құрудың стратегиялық қозғаушы күшіне айналды. Бұл эпизодтық цифрлық шешімдерден интеллектуалды оқыту платформалары, адаптивті оқыту орталары және мәтіндік, визуалды және мультимедиялық білім беру ресурстарын құруға қабілетті генеративті жасанды интеллект модельдері сияқты күрделі интеграцияланған жүйелерге көшуге мүмкіндік берді. Осыған байланысты зерттеу академиялық зерттеулердің тез өсіп келе жатқан көлемін жүйелеуге және білім берудегі жасанды интеллект туралы заманауи ғылыми дискурсты қалыптастыратын негізгі тенденцияларды, тұжырымдамалық кластерлерді және географиялық заңдылықтарды анықтауға бағытталған. Scopus дереккорынан алынған мәліметтер негізінде зерттеу басылымдардың динамикасын, жетекші журналдардың, авторлар мен мекемелердің және халықаралық ынтымақтастық желілерінің өнімділігі мен әсерін зерттейді. Генеративті ЖИ, жекелендірілген және бейімделгіш оқыту, тұрақты білім беру және ЖИ интеграциясының педагогикалық салдарларына, соның ішінде технология-ларды қабылдау мен оқушылар мен оқытушылардың мінез-құлық аспектілеріне қатысты тақырыптық салаларға ерекше назар аударылады. Зерттеу нәтижелері 2021 жылдан бастап жарияланым белсенділігінің айтарлықтай өскенін, шоғырландырылған және пәнаралық зерттеу саласының қалыптасуын көрсетеді. Тұтастай алғанда, нәти-желер жасанды интеллект автоматтандыру құралы ретінде ғана емес, сонымен қатар инновациялық, жекелен-дірілген және тұрақты білім беру экожүйелерін құрудың негізгі ресурсы ретінде қабылданатынын растайды.

Кілт сөздер: библиометриялық талдау, білім берудегі жасанды интеллект, генеративті ЖИ, білім беру мазмұны, білім берудің цифрлық трансформациясы, тұрақты білім беру.

ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ В ОБРАЗОВАНИИ КАК СПОСОБ ПОСТРОЕНИЯ ОБРАЗОВАТЕЛЬНОГО КОНТЕНТА: БИБЛИОМЕТРИЧЕСКИЙ АНАЛИЗ

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Аннотация. В данном исследовании представлен всесторонний библиометрический анализ международных научных публикаций, посвященных применению искусственного интеллекта (ИИ) при разработке и адаптации образовательного контента за период 2014-2024 годов. За последнее десятилетие искусственный интеллект превратился из вспомогательного технологического инструмента в стратегическую движущую силу образовательных преобразований, позволив перейти от эпизодических цифровых решений к сложным интегрированным системам, таким как интеллектуальные обучающие платформы, адаптивные среды обучения и генеративные модели искусственного интеллекта, способные создавать текстовые, визуальные и мультимедийные образовательные ресурсы. На этом фоне исследование направлено на систематизацию быстро растущего объема академических исследований и выявление ключевых тенденций, концептуальных кластеров и географических закономерностей, которые формируют современный научный дискурс об искусственном интеллекте в образовании. На основе данных, полученных из базы данных Scopus, в исследовании изучается динамика публикаций, продуктивность и влияние ведущих журналов, авторов и учреждений, а также международных сетей сотрудничества. Особое внимание уделяется тематическим областям, связанным с генеративным ИИ, персонализированным и адаптивным обучением, устойчивым образованием и педагогическими последствиями интеграции ИИ, включая принятие технологий и поведенческие аспекты учащихся и преподавателей. Результаты исследования свидетельствуют о заметном росте публикационной активности с 2021 года, что свидетельствует о формировании консолидированной и междисциплинарной исследовательской области. В целом, результаты подтверждают, что искусственный интеллект все чаще воспринимается не просто как инструмент автоматизации, но и как основополагающий ресурс для создания инновационных, персонализированных и устойчивых образовательных экосистем.

Ключевые слова: библиометрический анализ, искусственный интеллект в образовании, генеративный ИИ, образовательный контент, цифровая трансформация образования, устойчивое образование.

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