REVOLUTION IN LEARNING: INTEGRATION OF AI TOOLS INTO HIGHER EDUCATION — BIBLIOGRAPHICAL ANALYSIS

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Abstract

The rapid development of artificial intelligence, particularly generative AI tools, has significantly influenced higher education systems worldwide. In recent years, scholarly attention has increasingly focused on the educational potential of these technologies as well as on their ethical, institutional, and pedagogical implications. The aim of this paper is to identify key research trends and thematic areas related to the integration of artificial intelligence tools in higher education through a bibliometric analysis. The study is based on a dataset of 51 empirical articles indexed in the Web of Science database and published between 2021 and 2025. Data analysis and visualization were conducted using the VOSviewer software. The results reveal a substantial increase in research output after 2023, largely driven by the widespread adoption of generative AI tools such as ChatGPT. Major research themes include personalized learning, student performance and motivation, as well as issues related to academic integrity and critical thinking. The findings confirm the interdisciplinary nature of the research and indicate a shift from initial scholarly discussions to a more systematic examination of the impacts of artificial intelligence on the quality of higher education.

Key words:
artificial intelligence; generative artificial intelligence; higher education; bibliometric analysis; ChatGPT; academic integrity

JEL Classification I23, O33, C88 https://doi.org/10.52665/ser20250205

INTRODUCTION

Artificial intelligence refers to the ability of a digital machine to perform tasks commonly associated with intelligent beings. The development of artificial intelligence is significantly changing the ways in which people interact, communicate, live, learn and work. Artificial intelligence is currently becoming one of the main factors in the transformation of the modern education system, affecting not only teaching methods, but also the organization and management of educational institutions. Artificial intelligence systems are gradually becoming key in the individualization of teaching, automation of administrative tasks, or expanding access to education. Educational platforms are increasingly using artificial intelligence tools to support individualization of learning, automate selected pedagogical and administrative processes, and thus increase the efficiency of the higher education environment. Students no longer have access only to static learning materials, but are able to use intelligent tutoring systems that adapt to their individual pace and preferences.

1 LITERATURE OVERVIEW

Higher education has undergone significant changes in recent decades, primarily due to rapid technological advances that have disrupted conventional models of teaching and learning (Qolamani & Mohammed, 2023). The development of digital tools and innovations has also significantly impacted school teaching practices and administrative functions. In particular, artificial intelligence has become a transformative force in education. At its core, artificial intelligence refers to the development of computer systems capable of performing tasks that simulate human intelligence (Du-Harpur et al., 2020). The literature has confirmed the fact that systems that are based on artificial intelligence can adapt to the specific requirements and competencies of each student, thereby providing personalized feedback and

assistance to the student. Adaptive learning personalizes education by continuously evaluating each student's performance in real time and creating an ever-changing individualized learning path guided by artificial intelligence and machine learning, thereby increasing the quality of education and student satisfaction (Taylor et al., 2021). This integration of personalized and adaptive learning leads to more effective, efficient, and engaging learning experiences, and learning itself is tailored to the individual needs of students (Du Plooy et al., 2024). Empirical studies also indicate that students who use AI technologies as part of the learning process achieve, on average, better academic results than those students who rely exclusively on traditional teaching methods and procedures. This in turn confirms the fact that educational systems supported by AI tools can adapt content based on student performance and provide exactly what the student needs to improve their skills. In higher education, AI tools manifest themselves in various forms, such as tutoring systems, personalized learning platforms, adaptive assessment tools, and more (Bhutoria, 2022). Personalized education supported by AI tools can also help eliminate learning difficulties for marginalized students, students with special needs, etc. (Yonezawa et al., 2012). Generative AI refers to a type of AI that is capable of creating human-like content (e.g. text, narratives, visual artwork). This advanced system works by interpreting specific instructions or prompts to generate original and contextually relevant output, mimicking the creative processes observed in human cognition (Lim et al., 2023). Generative AI has gained a lot of attention from people from different backgrounds and professional fields after the launch of ChatGPT in November 2022 (Chavez et al., 2023). The launch of ChatGPT on the market and in practice has sparked many discussions about its potential application and use in education (Baabdullah, 2024). Educational institutions and researchers have presented many arguments from different perspectives, highlighting a number of advantages, but also expressing concerns related to the use of generative AI, e.g. in the form of ChatGPT (Ali et al., 2024a). Some studies suggest that one of the significant benefits of generative AI is related to personalized learning, accessibility, or even support for students with special needs (Korneeva et al., 2023; Lo, 2023; Yonezawa et al., 2012). Equally important, however, there have been legitimate concerns regarding, for example, the ethical implications of using AI tools. Because AI systems require vast amounts of data, including confidential information about students and faculty, this raises serious questions about privacy and data protection (Korneeva et al., 2023; Zawacki-Richter et al., 2019) and also, for example, plagiarism (Ali et al., 2024b; Tlili et al., 2023). Despite the significant potential of AI in supporting teaching and learning, its implementation in higher education also brings new ethical, pedagogical, and institutional risks that require systematic professional reflection. For example, in times of budget cuts, administrators may be tempted to replace teaching with profitable automated AI solutions. Faculty members, teaching assistants, student advisors, and administrative staff may fear that intelligent tutors, expert systems, and chatbots will take their jobs away (Zawacki-Richter et al., 2019). AI also plays a key role in the area of access to information. With advanced algorithms, it is possible to quickly analyze large amounts of data and identify relevant information, streamlining the way that scientific communities and individuals access new information in their fields. Digitization and artificial learning thus ensure that information is not only accessible but also tailored to the specific needs of users.

2 GOAL AND METHODOLOGY

The aim of our paper is to analyze the use of AI tools in the educational environment of universities and to identify factors that influence their implementation in higher education. That is, to answer the question: “What are the main topics (areas) of research on the use of AI tools in higher education and their key findings?” The search for relevant studies was carried out in the Web of Science database. The Web of Science (WoS) database was used to compile an initial set of articles due to its broad coverage of high-quality, peer-reviewed literature in the fields of education, technology and interdisciplinary

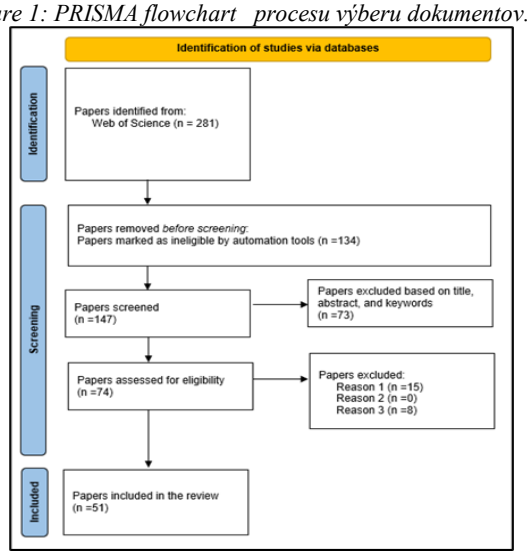
areas, thus ensuring the search for relevant empirical studies. The WoS database is a commonly used resource for systematic or bibliographic reviews of the literature. In November 2025, we conducted a search in the WoS database to find English publications that contain the terms artificial intelligence, higher education and empirical studies in the title, abstract or keywords. We used the search string listed in Table 1. Because many surveys show a rapid increase in publications focused on artificial intelligence (e.g., ChatGPT) since 2022, our review included studies from 2021 to 2025 to ensure a focus on the current state of the art in the field.

Table 1: Search string for identifying relevant studies in the WoS database

TITLE-ABS-KEY ("artificial intelligence")
AND
TITLE-ABS-KEY ("higher education ")
AND
TITLE-ABS-KEY ("empirical study" OR "empirical research" OR "experimental study" OR "case study")

As recommended by Chiu et al. (Chiu et al., 2023), we limited the search to categories related to AI research in higher education. This process was completed on November 30, 2025, resulting in 281 potential studies. We retained only full-text papers for further analysis, leaving us with 147 articles. We then performed manual screening using inclusion or exclusion criteria (Table 2) to assess the relevance of these articles to our focus. We screened the remaining studies based on their titles, abstracts, and keywords, and excluded studies that were not related to higher education, not related to artificial intelligence, not empirical, were conference papers, work in progress, reviews, meta-analyses, or had not been peer-reviewed. All publications that were considered irrelevant or lacking substantial content on AI in higher education were removed from our dataset. The selection process took place in several stages (Figure 1).

Figure 1: PRISMA flowchart – procesu výberu dokumentov.



Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. This work is licensed under CC BY 4.0. To view a copy of this license, visit https://creativecommons.org/licenses/by/4.0/

The final database contained 51 articles. We then performed a bibliometric analysis on these 51 articles. Bibliometric analysis involves quantitatively summarizing the metadata of large-scale research articles, including year of publication, title, abstract, citations, authors, and institutions. It serves as an effective method for understanding the state of a research field, especially when the scope of the review is broad and the dataset is too large to be manually reviewed (Donthu et al., 2021). The analysis was performed using VOSviewer software.

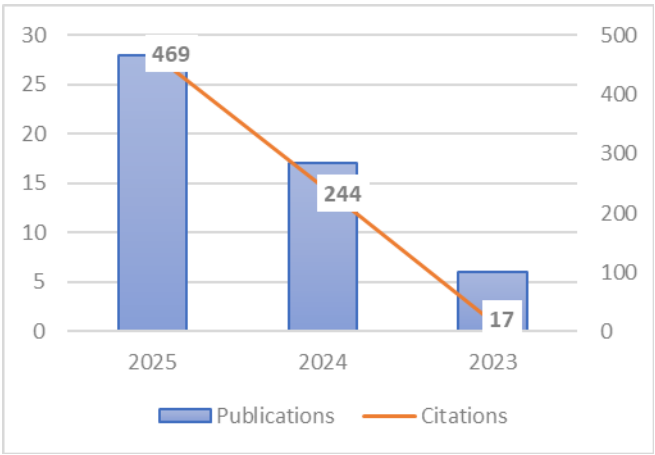
Table 2: Inclusion/exclusion criteria.

Reason	Studies were included if:	Studies were excluded if:
1.	Focused on the application, integration, or impact of artificial intelligence in higher education contexts.	It did not explicitly address artificial intelligence or its applications in education.
2.	Was the research empirical, using experimental, quasi-experimental, or other data-driven research methods?	They were secondary sources (e.g., reviews, opinion articles, meta-analyses).
3.	They have been published in peer-reviewed journals.	These were conference papers, theses, dissertations, or works in progress.

3 FINDINGS

Identifying research trends helps us understand the current state of AI in higher education and reveals where scholarly and institutional attention is most focused. We examined the following key dimensions: year of publication, country of study, citation analysis, keyword analysis.

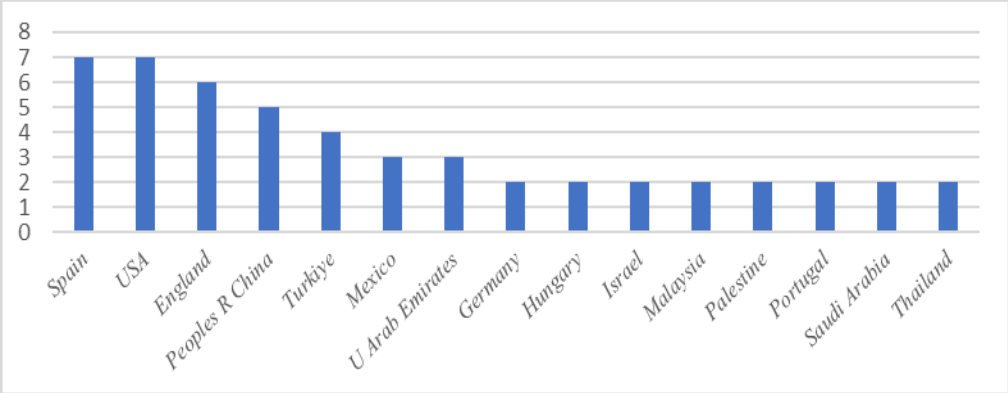
Figure 2: Development of the number of publications and citations depending on the year of publication



Source: Web of Science

The data shown in Figure 1 shows a significant time trend in the number of published articles in individual years focused on the integration of artificial intelligence tools into higher education. The lowest number of identified articles was recorded in 2023 (6 articles). In the following year, 2024, there was a 284% increase in scientific production to 17 articles, which is evidence of the growing research interest in this topic in the academic community. The highest number of publications was recorded in 2025, namely 28 articles, which represents a more than fourfold increase compared to 2023.

Figure 3: Number of publications by country



Source: Web of Science

Among the 48 countries identified, Spain and the USA show the highest production of scholarly articles focused on the use of AI tools in higher education in our analysis. Such high publication activity in these countries may be related to their long-term focus on research into educational activities as well as the rapid adoption of generative AI tools in their academic environment. The following countries, such as England and the People's Republic of China, show a slightly lower, but still significant number of publications. Most other countries are represented by only one or two articles, which points to the geographically dispersed nature of research and the absence of dominant national research centers in this area. At the same time, there is no significant author dominance, since the maximum number of published articles per author is one, which may indicate the initial phase of the formation of the research community and the high degree of interdisciplinarity of the research area under study.

Citation analysis identified six highly cited articles in the analyzed set. The most cited publication was published in the journal Education Sciences and accumulated 309 citations, corresponding to an average of 77.25 citations per year. Other highly cited articles were published in the journals Cogent Education (120 citations), Computers and Education Open (53 citations), International Journal of Educational Technology in Higher Education (46 citations), Smart Learning Environments (32 citations), and Education and Information Technologies (30 citations). All journals in which the most cited articles were published are indexed in the Web of Science Core Collection. The articles appeared predominantly in journals ranked in the first quartile (Q1) of the Education & Educational Research category with journal impact factors ranging from approximately 5 to more than 16, while Cogent Education had a journal citation indicator close to the disciplinary average (JCI ≈ 0.97).

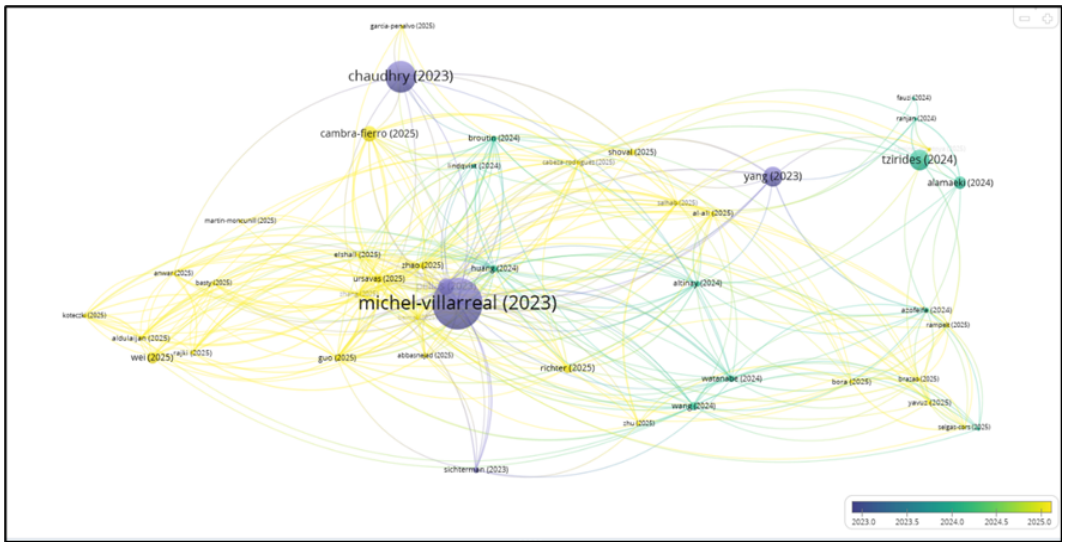
Table 3: Most cited publications and author

Publications	citations		magazín
	average per year	total	country
Michel-Villarreal, R. ; Vilalta-Perdomo, E ; (...); Gerardou, FS: ***Challenges and Opportunities of Generative AI for Higher Education as Explained by ChatGPT*** (2023)	77,25	309	EDUCATION SCIENCES England
Chaudhry, IS ; Sarwary, SAM ; (...); Chabchoub, H.: ***Time to Revisit Existing Student's Performance Evaluation Approach in Higher Education Sector in a New Era of ChatGPT — A Case Study*** (2023)	30	120	COGENT EDUCATION Spojené arabské emiráty
Tzirides, AO ; Zapata, G. ; (...); Kalantzis, M.: ***Combining human and artificial intelligence for enhanced AI literacy in higher education*** (2024)	17,67	53	COMPUTERS AND EDUCATION OPEN USA
Yang, Qifan ; Lian, LW a Zhao, JH: ***Developing a gamified artificial intelligence educational robot to promote learning effectiveness and behavior in laboratory safety courses for undergraduate students*** (2023)	11,75	46	INTERNATIONAL JOURNAL OF EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION China
Pellas, Nikolaos: ***The influence of sociodemographic factors on students' attitudes toward AI-generated video content creation*** (2023)	8	32	SMART LEARNING ENVIRONMENTS Grécko
Cambra-Fierro, JJ ; Blasco, MF ; (...); Trifu, A. **ChatGPT adoption and its influence on faculty well-being: An empirical research in higher education** (2025)	10	30	EDUCATION AND INFORMATION TECHNOLOGIES Spain

Source: https://www.webofscience.com/wos/woscc/citation-report/c0b67784-d6ef-4392-9eb2-9ac63ee364c3-01957e0582

The temporal visualization of the most cited authors provides insight into the dynamics of research development in the field of integrating AI tools into higher education in the monitored period. The color spectrum of the nodes reflects the chronological aspect of publication activity, with older works shown in cooler shades and newer publications in warmer colors. It is clear from the visualization that a significant increase in publication and citation activity occurs after 2023, which corresponds to the spread of generative AI tools and their rapid adoption in the academic environment. Authors publishing in 2024 and 2025 create denser connections, which indicates the growing intensity of scientific discussion and the gradual consolidation of the research field. Older works from 2023 and earlier periods fulfill the function of theoretical starting points in the network, which are followed by newer empirical and application-oriented studies.

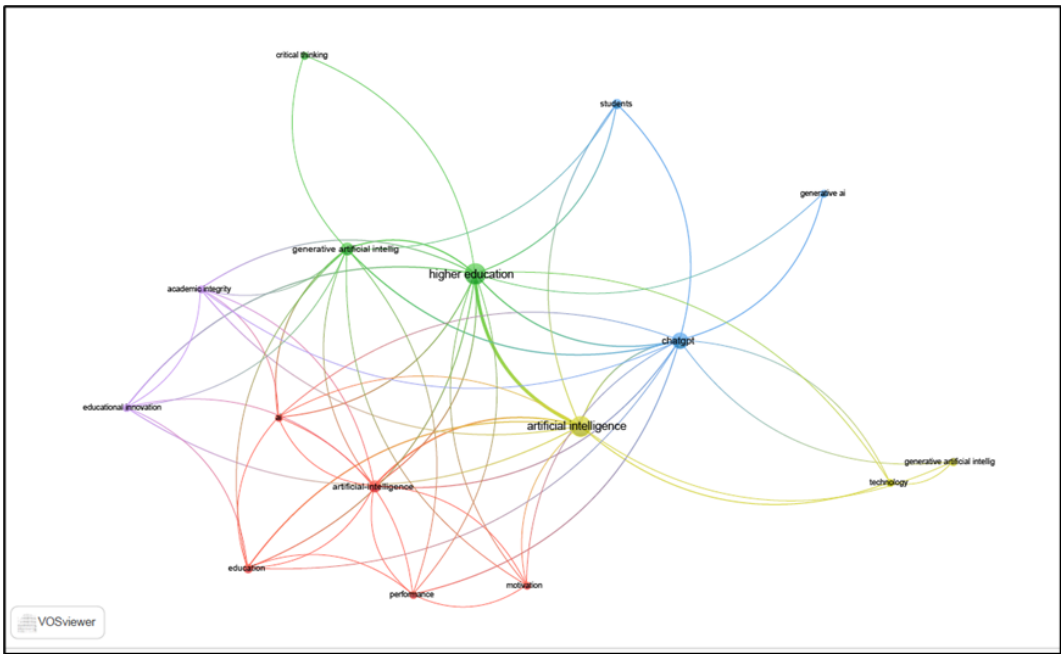
Figure 4: Visualization, ktorá znázorňuje sieť najcitovanejších autorov v čase



Source: processed using the VOSviewer software tool

Figure 3 shows a network visualization of the co-occurrence of keywords in the field of integrating artificial intelligence tools into higher education, created using the VOSviewer software. The size of the nodes represents the frequency of occurrence of individual keywords, while the thickness of the links reflects the strength of their mutual relationships. The color distinction of the nodes points to thematic clusters within the analyzed research field.

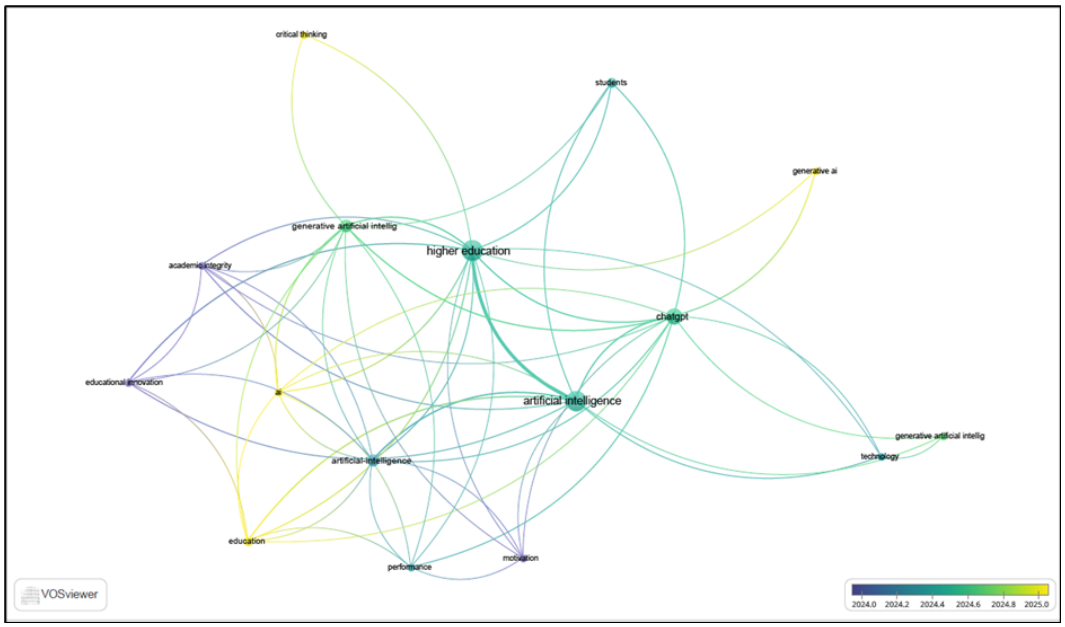
Figure 5: Visualization of relationships between keywords - thematic areas of research



Source: processed using the VOSviewer software tool

Figure 4 shows us a temporal visualization of keywords in the analyzed set. Through this analysis, we can identify how research content changes over time.

Figure 6: Visualization of network relationships between keywords with timeline



Source: processed using the VOSviewer software tool

4 DISCUSSION

The results of the bibliographic analysis point to a significant acceleration of research aimed at integrating artificial intelligence tools into higher education, which is closely related to the rapid development of generative artificial intelligence in recent years. In particular, the emergence of large-scale language models, such as ChatGPT, has fundamentally influenced the direction of research discourse and initiated an intensive professional discussion about their pedagogical potential, as well as the risks associated with their use in an academic environment. The wide availability of these tools creates increased pressure to address ethical, didactic and institutional issues, which is also reflected in the growing number of scientific outputs in this area. The findings indicate that this is a dynamically developing research area, in which a further increase in publication activity can be expected in the near future. The distribution of highly cited publications in internationally recognized journals (Cogent Education, Computers and Education Open, Education Sciences...) and across multiple geographical regions points to the strong global visibility and interdisciplinary nature of research focused on artificial intelligence in higher education. The most frequently cited works focus primarily on the analysis of the impacts of generative artificial intelligence on the process of learning, teaching and student assessment. The authors identify several potential benefits, including personalization of learning, continuous support for students, relieving teachers of routine tasks, and creating innovative educational experiences. At the same time, however, they point out significant risks, especially in the areas of academic integrity, ethics, security, quality and reliability of the information generated, as well as possible implementation barriers and the risk of overreliance on artificial intelligence tools (Michel-Villarreal et al., 2023). Particular attention is paid to the question of the extent to which current assessment approaches are able to adequately capture the development of key student competencies in an environment where generative AI tools are readily available.

Research in this area reflects the need to reconsider traditional forms of assessment and emphasizes the importance of developing critical thinking, problem-solving, communication and ethical skills. At the same time, it is shown that a suitably designed combination of human intelligence and artificial intelligence can support the development of students' AI literacy, especially through collaborative and participatory teaching strategies that lead to the conscious, critical and ethical use of AI tools in learning (Tzirides et al., 2024). The results also point to the expanding research interest in innovative didactic approaches, such as the use of gamified educational robots or intelligent systems, which can positively affect learning outcomes, student motivation and reducing cognitive load (Yang et al., 2023). At the same time, it is confirmed that the acceptance of AI tools by students is influenced by several factors, such as age, previous technological experience or participation in AI education. Although the overall attitude of students towards AI is largely positive, research points to ongoing ethical challenges, issues of inclusion and the need for systematic integration of AI education into higher education curricula (Pellas, 2023). An interesting finding is also the impact of the use of generative AI on the well-being of university educators, as the results indicate the potential of AI tools to contribute to reducing stress and increasing work well-being (Cambra-Fierro et al., 2025). Citation analysis indicates a shift in research interest from initial conceptual and exploratory approaches to more systematic exploration of the effectiveness, ethical implications and long-term sustainability of integrating AI into higher education. This trend confirms that the field is maturing and gradually moving towards a deeper reflection on the impacts of AI on the quality of education and academic values.

The results of the keyword analysis support these findings. The dominant position of the terms artificial intelligence, higher education and ChatGPT in the network indicates a strong orientation of current research on generative AI in the academic context. Links with terms such as students, performance and motivation reflect the growing interest in empirically assessing the impacts of AI tools on student outcomes and engagement. A separate thematic cluster focused on academic integrity and critical thinking highlights the ethical and pedagogical challenges that accompany the implementation of generative AI, and points to the need for systematic development of critical thinking as a key competence in the era of artificial intelligence. At the same time, the cluster focused on educational innovation and technology indicates that AI is perceived not only as a technological tool, but also as a significant catalyst for pedagogical innovation. The temporal analysis of keywords shows that research has evolved from general topics related to education and technology to a more detailed examination of specific aspects of the educational process. The latest publications reflect the rapid response of the academic community to the advent of generative artificial intelligence and at the same time point to a shift from technological enthusiasm to a deeper analysis of the pedagogical, evaluative and ethical implications of its use. This development confirms that research on the integration of artificial intelligence into higher education is in a transitional phase towards a systematic and critically reflected examination of its impacts on the quality of learning, student assessment and the preservation of academic values.

This study contributes to the theoretical discourse on artificial intelligence in higher education by systematizing existing empirical evidence into a coherent thematic structure. By identifying dominant and emerging research clusters, the paper provides a conceptual map that supports theory-building in AI-supported learning, academic integrity, and institutional adaptation.

This study has several limitations. First, the analysis was limited to the Web of Science database, which may exclude relevant studies indexed elsewhere. Second, bibliometric methods capture research trends but do not assess the pedagogical effectiveness of AI tools. Future research should therefore combine bibliometric approaches with qualitative and longitudinal empirical studies.

CONCLUSION

The presented bibliometric analysis confirms that research on the integration of artificial intelligence tools into higher education is a dynamically developing and interdisciplinary field. The results of our analysis point to a significant increase in research activity after 2023, which is closely related mainly to the spread of generative AI tools, especially ChatGPT, in the academic environment. The dominant research topics focus on personalized learning, academic performance and student motivation, with increasing emphasis also on issues of academic integrity and the development of critical thinking. From a practical point of view, the findings have significant practical implications for colleges and universities. They point to the need for systematic and pedagogically sound integration of artificial intelligence tools into the educational process, as well as the necessity of creating institutional strategies and ethical frameworks that will reflect the new challenges associated with their use. The development of teachers' and students' competencies in the area of critical and responsible use of generative artificial intelligence requires special attention. In terms of future research, empirical and comparative studies focusing on the long-term pedagogical impacts of the use of AI tools, as well as research on their impact on student assessment, academic integrity and equality of access to education, seem promising. Further research should also focus on the institutional and organizational aspects of the implementation of artificial intelligence tools in higher education, in order to support their meaningful and sustainable use in academic practice. Overall, the results point to the strongly interdisciplinary nature of the research area.

ACKNOWLEDGMENTS

Implementácia nových požiadaviek trhu práce do vzdelávania personálnych manažérov v oblasti digitálnych zručností. Grantová agentúra: KEGA Evidenčné číslo projektu: 007TnUAD-4/2025

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