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PEDAGOGICAL POTENTIAL OF ARTIFICIAL INTELLIGENCE IN THE DEVELOPMENT OF STUDENTS' DIGITAL COMPETENCIES: A REVIEW OF CURRENT RESEARCH

Abstract

This article analyzes the pedagogical potential of artificial intelligence technologies in developing digital competencies in higher education students, focusing on the contradiction between the rapid adoption of AI in educational practice and the lack of a systematic understanding of its impact on the structure of digital literacy. The study's methodological basis is a systematic literature review according to the PRISMA 2020 protocol using Scopus data from 2010 to 2025. Using six targeted search combinations, a bibliometric analysis was conducted, covering publication dynamics, document typology, and the maturity of research areas. After screening and thematic classification, 28 articles from journals ranked Q1-Q4 were analyzed.

The results revealed five key thematic clusters: conceptualization and measurement of students' AI/digital literacy; teacher competencies and institutional conditions for AI use; the impact of generative AI and chatbots on the development of digital skills; the use of learning analytics to support self-regulation and data management; strategic and methodological reviews of AI integration in higher education. Bibliometric data show exponential growth in research on generative AI and a steady expansion of work on digital skills. Analysis has shown that AI can enhance the development of digital competencies only in the presence of thoughtful pedagogical design, developed AI competencies of teachers, and ethically sound institutional frameworks.

The scientific novelty of the study lies in the formation of an analytical framework that describes AI as a multi-level pedagogical factor influencing the structure of students' digital competencies and revealing prospects for further research, including analysis of long-term effects, the context of developing countries, and the integration of AI into university digital transformation strategies.

Keywords: artificial intelligence, digital competencies, AI literacy, higher education, generative AI, learning analytics.

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СТУДЕНТТЕРДІҢ ЦИФРЛЫҚ ҚҰЗЫРЕТТІЛІГІН ҚАЛЫПТАСТЫРУДАҒЫ ЖАСАНДЫ ИНТЕЛЛЕКТТІҢ ПЕДАГОГИКАЛЫҚ ӘЛЕУЕТІ: ЗАМАНАУИ ЗЕРТТЕУЛЕРГЕ ШОЛУ

Аңдатпа

Мақала жоғары мектеп студенттерінің цифрлық құзыреттіліктерін қалыптастырудағы жасанды интеллект технологияларының педагогикалық әлеуетін талдайды, білім беру практикасына жасанды интеллектті жедел енгізу мен оның Цифрлық сауаттылық құрылымына әсерін жүйелі түсінбеушілік арасындағы қайшылықтарға назар аударады. Зерттеудің әдіснамалық негізі 2010-2025 жылдардағы Scopus деректерін пайдалана отырып, Prisma 2020 хаттамасы бойынша жүйелі әдеби шолу болып табылады. Алты мақсатты іздеу комбинациясы негізінде басылымдардың динамикасын, құжаттардың типологиясын және зерттеу бағыттарының жетілуін қамтитын библиометриялық талдау жүргізілді. Скринингтен және тақырыптық жіктеуден кейін Q1-Q4 журналдарынан 28 мақала талданды.

Нәтижелер бес негізгі тақырыптық кластерді анықтады: студенттердің ЖИ/цифрлық сауаттылығын тұжырымдамалау және өлшеу; оқытушылардың құзыреттіліктері және жасанды интеллектті пайдаланудың институционалдық жағдайлары; генеративті ЖИ мен чатботтардың сандық дағдыларды дамытуға әсері; өзін-өзі реттеуді және деректерді басқаруды қолдау үшін оқыту аналитикасын пайдалану; және жоғары білім берудегі ЖИ интеграциясының стратегиялық және әдіснамалық шолулары. Библиометриялық деректер генеративті ЖИ бойынша зерттеулердің экспоненциалды өсуін және сандық дағдылар бойынша жұмыстың тұрақты кеңеюін құжаттайды. Талдау ЖИ сандық дағдыларды дамытуды тек ойластырылған педагогикалық дизайн, жақсы дамыған оқытушылардың жасанды интеллект құзыреттіліктері және этикалық тұрғыдан негізделген институционалдық құрылымдар арқылы ғана жақсарту алатынын көрсетті.

Зерттеудің жаңалығы ЖИ студенттердің цифрлық құзыреттілік құрылымдарына әсер ететін көп деңгейлі педагогикалық фактор ретінде сипаттайтын және ұзақ мерзімді әсерлерді талдауды, дамушы елдердің мәнісін

және ЖИ университеттердің цифрлық трансформация стратегияларына интеграциялауды қоса алғанда, одан әрі зерттеу жолдарын ашатын аналитикалық құрылымды әзірлеуде жатыр.

Түйін сөздер: жасанды интеллект, цифрлық құзыреттіліктер, ЖИ сауаттылығы, жоғары білім, генеративті ЖИ, оқыту аналитикасы.

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ПЕДАГОГИЧЕСКИЙ ПОТЕНЦИАЛ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В ФОРМИРОВАНИИ ЦИФРОВЫХ КОМПЕТЕНЦИЙ СТУДЕНТОВ: ОБЗОР СОВРЕМЕННЫХ ИССЛЕДОВАНИЙ

Аннотация

Статья анализирует педагогический потенциал технологий искусственного интеллекта в формировании цифровых компетенций студентов высшей школы, акцентируя внимание на противоречии между стремительным внедрением ИИ в образовательную практику и отсутствием системного понимания его влияния на структуру цифровой грамотности. Методологической основой исследования выступает систематический литературный обзор по протоколу PRISMA 2020 с использованием данных Scopus за 2010-2025 гг. На основании шести целевых поисковых комбинаций проведён библиометрический анализ, охватывающий динамику публикаций, типологию документов и зрелость исследовательских направлений. После скрининга и тематической классификации проанализировано 28 статей из журналов Q1-Q4.

Результаты выявили пять ключевых тематических кластеров: концептуализация и измерение ИИ-/цифровой грамотности студентов; компетенции преподавателей и институциональные условия использования ИИ; влияние генеративного ИИ и чат-ботов на развитие цифровых навыков; применение аналитики обучения для поддержки саморегуляции и работы с данными; стратегические и методологические обзоры интеграции ИИ в высшее образование. Библиометрические данные фиксируют экспоненциальный рост исследований генеративного ИИ и устойчивое расширение работ, посвящённых цифровым навыкам. Анализ показал, что ИИ способен усиливать развитие цифровых компетенций только при наличии продуманного педагогического дизайна, развитых ИИ-компетенций преподавателей и этически выверенных институциональных рамок.

Научная новизна исследования заключается в формировании аналитической рамки, описывающей ИИ как многоуровневый педагогический фактор, влияющий на структуры цифровых компетенций студентов и раскрывающий вающихся стран и интеграцию ИИ в стратегии университетской цифровой трансформации. перспективы дальнейших исследований, включая анализ долгосрочных эффектов, контекст разви

Ключевые слова: искусственный интеллект, цифровые компетенции, ИИ-грамотность, высшее образование, генеративный ИИ, аналитика обучения.

Introduction. The rapid development of artificial intelligence (AI) technologies has radically changed the context of higher education: intelligent learning systems, adaptive platforms, educational analytics, and generative models (ChatGPT, Gemini, Claude, Copilot, etc.) are being actively integrated into the learning process, shaping new ways for students to work with data, communicate, and self-regulate. In this environment, digital competencies are becoming a key outcome of university education and an essential part of human capital. Traditional ideas about digital literacy no longer meet the requirements of the “AI era”: modern students must be able to critically interact with algorithmically generated content, understand the principles of AI systems, evaluate the transparency of automated solutions, adhere to academic integrity standards, and use data for educational and career decisions.

The growing demands of the labor market make digital and AI competencies mandatory for graduates, prompting universities to update their curricula and adopt new teaching models. However, despite the increase in the number of publications on AI in education, research remains fragmented: the focus is divided between individual tools, measurement scales, the perception of AI by students and teachers, and ethical and legal aspects. At the same time, the development of digital competencies as a comprehensive educational outcome often finds itself on the periphery, and interpretations of the concept itself vary significantly.

Thus, a scientific gap is revealed: there are no systematic reviews that specifically examine the pedagogical potential of AI in the development of students' digital competencies, compare different

areas of research, and identify their limitations, including the lack of empirical data in developing countries.

The purpose of this article is to use the systematic literature review (SLR, PRISMA 2020) methodology to summarize current research on the pedagogical potential of AI in the formation of students' digital competencies, identify key areas, results, and methodological deficiencies, and outline prospects for further work. To achieve this goal, search strategies, bibliometric dynamics of publications, content clusters of research (AI literacy, teacher competencies, generative AI, learning analytics, etc.), limitations of existing work, and practical guidelines for educational policy are analyzed.

The article aims to fill the identified GAP by offering a comprehensive analytical framework in which AI is considered not only as a technological innovation but also as a pedagogical resource for the development of digital competencies in the context of the digital transformation of higher education.

Materials and methods. The methodological basis of the study is a systematic literature review (SLR) approach, constructed in accordance with the PRISMA 2020 principles. This protocol provides for the following sequential steps: formation of a search strategy, screening of sources, assessment of their compliance with inclusion criteria, data extraction, and final synthesis of results. The PRISMA methodology ensures transparency in the selection of publications, reproducibility of results, and minimization of subjectivity, which makes the review compliant with current international requirements for scientific research.

The search for sources was conducted in the Scopus scientific database, covering the period 2010-2025. This database was chosen because of its status as one of the most authoritative scientific citation indexes, covering a wide range of research in the fields of pedagogy, digital technologies, and artificial intelligence.

2.1. Search strategy and keyword formula

- To identify relevant literature, several combinations of keywords reflecting the relationship between artificial intelligence, digital competencies, and higher education were formed and tested. The results of search queries as of November 16, 2025 are presented below.

- AI; Education; University – 421 documents found. The search results are visualized in Figures 1 and 2.

- Artificial intelligence; Digital competencies; Higher education – 14 documents found. Analytical graphs are shown in Figures 3 and 4.

- Learning using artificial intelligence; Digital literacy – 199 documents found. Detailed analysis – Figures 5 and 6.

- Adaptive learning; University students; Artificial intelligence – 11 documents found. Results are presented in Figures 7 and 8.

- Generative AI; Education – 2,038 documents found. Illustrative analysis – Figures 9 and 10.

- Education; Digital skills; Artificial intelligence – 158 documents found. Diagrams and distributions – Figures 11 and 12.

The use of several combinations of keywords ensured the completeness of the sample and avoided the loss of relevant studies related to various areas of application of artificial intelligence in the digital training of students.

2.2. Criteria for inclusion and substantive analysis of sources

The following criteria were used to select publications:

1. Source type: articles in peer-reviewed scientific journals indexed in Scopus (Q1-Q4).

2. Research subject: direct study of the application of artificial intelligence technologies in teaching digital literacy and digital competencies.

3. Target audience: higher education students; teachers involved in digital or blended learning.

4. Research methodology: experimental studies; quantitative and qualitative methods; mixed methods; systematic, thematic, and meta-analytical reviews.

Sources that did not meet the specified criteria, as well as duplicate publications, were excluded at the screening stage in accordance with the PRISMA 2020 protocol (Table 1).

Table 1. Stages of publication selection according to the PRISMA 2020 protocol

PRISMA stage	Description of actions	Number of publications (n)
Identification	Search for publications in the Scopus database using six combinations of keywords (2010-2025)	2 841
	Duplicate entries deleted	– 317
Total after removing duplicates		2 524
Screening	Selection by title, abstract, keywords; exclusion of irrelevant articles	– 2 397
Publications after screening		127
Evaluation of full-text sources (Eligibility)	Analysis of full texts for compliance with inclusion criteria (AI topics, digital literacy/competencies, students/teachers, research methods)	127
	Excluded after reading the full text (does not meet criteria, poor methodology, different focus)	– 99
Publications included in the analytical SLR		28
Included	Final set of works included in the content analysis and comparative table 3	28

Results and discussion 3.1. Analysis of publication activity and type of scientific works

Analysis of publication activity for the query “AI; Education; University” in the Scopus database for the period 2010-2025. This allows us to identify the dynamics of research development at the intersection of artificial intelligence and higher education. This search query covers the broadest range of scientific works devoted to the integration of AI technologies into the university environment, the educational process, and the development of students' digital skills. The visual data presented in Figures 1 and 2 make it possible to assess not only the quantitative growth of interest in the subject, but also the structure of publication types, which is important for understanding the nature of scientific discourse and the degree of methodological maturity of the research field.

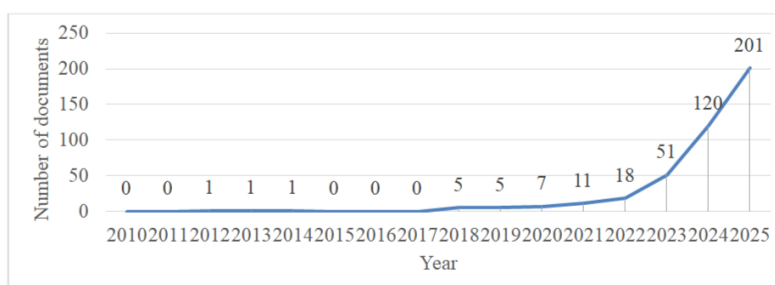


Figure 1. Number of articles found by searching for keywords in the Scopus database “AI; Education; University” for 2010-2025

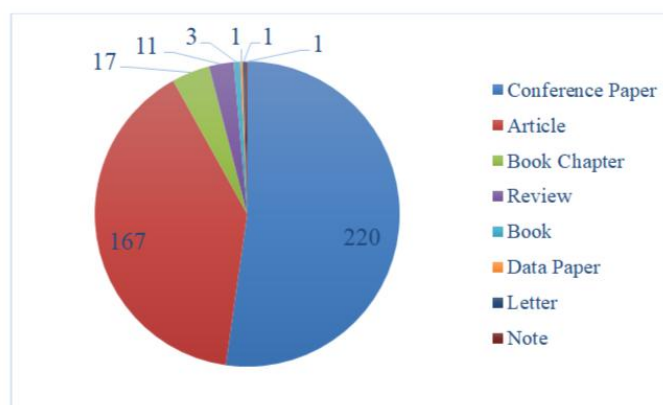


Figure 2. Types of articles by keyword search in the Scopus database “AI; Education; University” for 2010-2025

The data in Figures 1 and 2 show that research in the field of artificial intelligence in higher education has gone from being a marginal topic to a rapidly developing scientific field: in 2010-2016, interest was minimal (no more than 1-2 publications per year), but since 2017, there has been steady growth, coinciding with the spread of adaptive platforms, intelligent learning systems, and educational analytics tools. A particularly noticeable increase begins after 2021, when the number of works doubles against the backdrop of global digitization of education and the transition to blended learning, and in 2024-2025, there is a sharp jump from 51 to 201 publications, driven by explosive interest in generative models such as ChatGPT, Claude, and Gemini, which have radically changed educational practices. The structure of publications also testifies to the maturity of the field: conference reports (220) dominate, reflecting the innovative nature of research and its prompt discussion at scientific forums; in second place are articles in peer-reviewed journals (167), confirming the formation of a stable academic base; the presence of book chapters (17) and reviews (11) indicates the accumulation of theoretical generalizations. Taken together, these data demonstrate that over the past five years, the field of “AI in higher education” has moved from a peripheral status to a dynamic, methodologically diverse, and scientifically significant area, underscoring the need for a systematic literature review and in-depth analysis of the growing body of research.

The next stage of the bibliometric analysis was to study publication activity using a narrower combination of keywords: “Artificial intelligence; Digital competencies; Higher education.” This query allows us to identify the most relevant set of scientific works directly devoted to studying the impact of artificial intelligence technologies on the formation of digital competencies in the university environment. Since these three concepts refine the subject of the study and limit the sample to mainly conceptual and empirical works of recent years, the search results demonstrate the underlying trends in the development of this scientific field. The visual materials presented in Figures 3 and 4 allow us to assess the dynamics of the number of publications for 2020-2025 and the structure of document types, which is important for understanding the maturity of the subject area and the nature of scientific discourse.

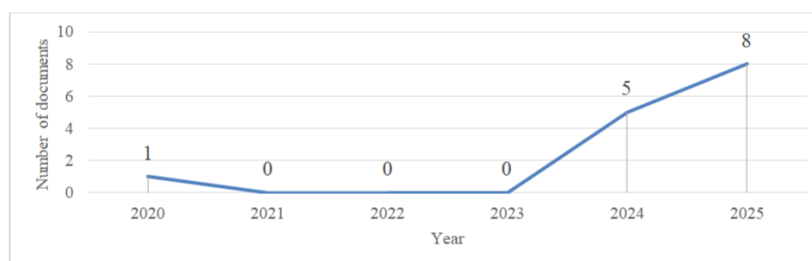


Figure 3. Number of articles found by searching for keywords in the Scopus database: “Artificial intelligence; Digital competencies; Higher education” for 2020-2025

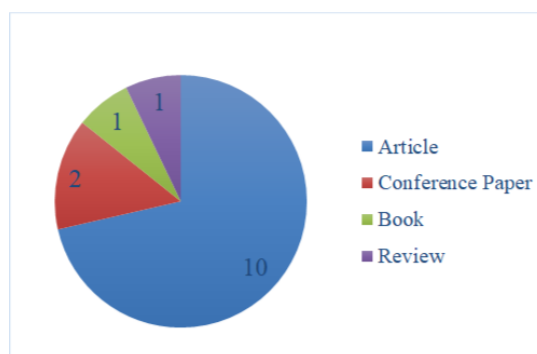


Figure 4. Types of articles found by keyword search in the Scopus database for “Artificial intelligence; Digital competencies; Higher education” for 2020-2025

The data in Figures 3 and 4 show that research combining artificial intelligence, digital skills, and higher education into a single analytical framework has emerged relatively recently and has only shown steady positive growth since 2023: while only one publication was registered in 2020 and there were no publications at all in 2021-2022, the number of articles increased to five in 2024 and reached eight in 2025, indicating the emergence of this topic as an independent area of scientific research. The structure of publications also reflects the nature and maturity of the research discourse: articles in peer-reviewed journals (10) dominate, indicating the high academic status of the topic and its inclusion in international scientific discussion; conference reports (2) rank second, which is natural for innovative areas where preliminary results are promptly presented at scientific forums; individual books and reviews demonstrate the initial stage of the formation of a theoretical basis. Taken together, these data confirm that research on the role of artificial intelligence in the development of students' digital competencies is in a phase of active growth, characterized by an expansion of methodological and thematic coverage, and requires further systematization, which justifies the relevance of the literature review conducted.

To gain a deeper understanding of how scientific discourse is developing at the intersection of artificial intelligence and digital literacy, a separate bibliometric search was conducted using the keywords “Learning using artificial intelligence; digital literacy.” This combination reflects research focusing not only on the application of AI in education, but also on developing students' skills in working with digital information, digital security, and critical data analysis. The sample covers publications from 2010 to 2025 and allows us to assess the level of interest in the topic and determine which types of scientific documents are most characteristic of this field. The visual data presented in Figures 5 and 6 demonstrate the growth dynamics of the number of publications and their typological distribution.

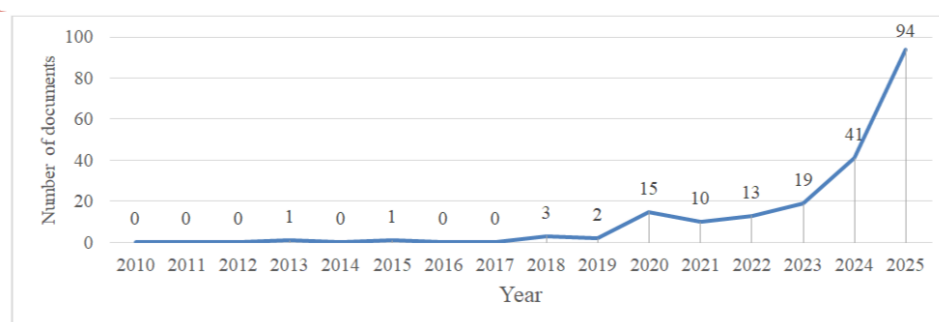


Figure 5. Number of articles found by searching for the keywords “Learning using artificial intelligence; digital literacy” in the Scopus database for 2010-2025

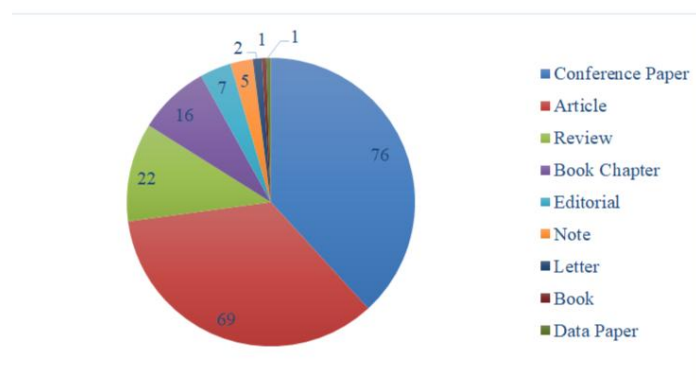


Figure 6. Types of articles found by keyword search in the Scopus database for “Learning using artificial intelligence; digital literacy” for 2010-2025

Figures 5 and 6 demonstrate the rapid and almost exponential development of research dedicated to the use of artificial intelligence for the formation of digital literacy. While publication activity remained at a minimum level between 2010 and 2017 (0-1 article per year), reflecting the early stage of development of this topic, since 2018 there has been a noticeable increase in interest, which has turned into a steady upward trajectory since 2020 against the backdrop of the mass transition of education systems to digital formats during the pandemic. The sharpest jump was recorded in 2024-2025, when the number of publications increased from 41 to 94, indicating a significant increase in researchers' attention to digital literacy in the context of the widespread introduction of generative AI models and the emergence of new educational analytics tools. The structure of the documents, shown in Figure 6, further confirms the maturity and diversity of scientific discourse: the predominance of conference proceedings (76) and peer-reviewed articles (69) indicates a high intensity of scientific communication, while a significant number of reviews (22) and book chapters (16) indicate the active accumulation and systematization of theoretical approaches. Less common formats – editorial materials, letters, books – are indicators of the expansion of the field of research and the involvement of different types of scientific publications. Overall, the data shows that research into the application of AI for the development of digital literacy has reached a stage of active growth and institutionalization, becoming one of the key and promising areas of modern digital pedagogy.

To clarify the nature of scientific discourse and determine the degree of maturity of research related to adaptive learning and the use of artificial intelligence in working with university students, a separate bibliometric search was conducted using the keywords “Adaptive learning; university students; artificial intelligence.” This combination allows us to identify publications that focus on the role of AI in individualizing learning trajectories, adapting learning materials, and assessing student performance. Since adaptive learning is one of the key areas of AI implementation in higher education, the analysis of publication dynamics and document type structure is of considerable interest. The visual results are presented in Figures 7 and 8.

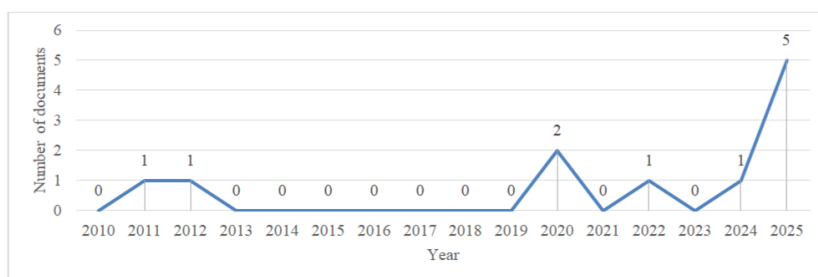


Figure 7. Number of articles found by searching for the keywords “Adaptive learning; university students; artificial intelligence” in the Scopus database for 2010-2025

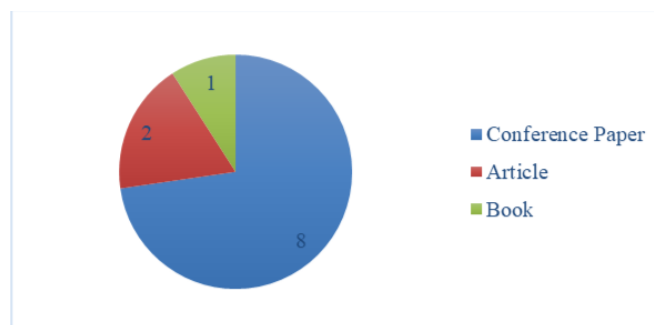


Figure 8. Types of articles found by searching for keywords in the Scopus database: “Adaptive learning; university students; artificial intelligence” for 2010-2025

The data in Figures 7 and 8 show that research on adaptive learning using artificial intelligence in a university environment has remained a developing and small field for a long time: in 2010-2012, there were only a few publications, and in 2013-2018, there was a complete hiatus in publishing activity, reflecting both the technological immaturity of adaptive systems and the lack of integrated models for the application of AI in higher education. Only since 2020, against the backdrop of accelerated digitalization of education, has the first noticeable surge (2 publications) appeared, followed by wave-like dynamics of interest in 2022 and 2024. The most significant growth is observed in 2025, when the number of publications reaches five, indicating the formation of sustained scientific interest in AI-based adaptive educational models. The typological structure of publications confirms the early stage of institutionalization: the dominance of conference reports (8) indicates the experimental nature of research and active discussion of new models on scientific platforms; peer-reviewed articles (2) reflect the initial penetration of the topic into academic journals, and the appearance of a single book indicates the first attempts to systematize the theoretical basis. Taken together, these data show that research on adaptive learning using AI is in its infancy, but is demonstrating accelerating growth and increasing interest from the scientific community, which underscores the need for further analysis and systematization of approaches to the development of adaptive educational models in the context of the digital transformation of higher education.

One of the most significant areas of contemporary educational discourse is the study of the impact of generative artificial intelligence (Generative AI) on the education system. The emergence of new-generation models such as ChatGPT, Gemini, Claude, Copilot, and others – has led to a sharp increase in researchers' interest in issues related to their pedagogical application, ethical implications, impact on learning outcomes, and the formation of digital competencies. To identify the scale of scientific activity, a bibliometric search was conducted using the keywords “Generative AI; Education” for the years 2020-2025.

The data presented in Figures 9 and 10 allow us to assess not only the dynamics of publications in this field, but also the typology of scientific documents, which is important for understanding the structure and maturity of the research direction, as well as for identifying the main forms of scientific communication characteristic of a rapidly developing technological sphere.

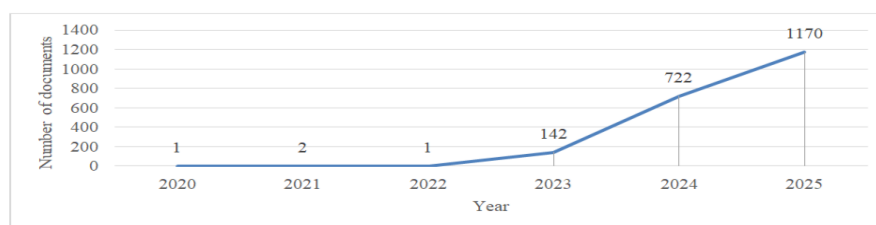


Figure 9. Number of articles found by keyword search in the Scopus database “Generative AI; Education” for 2020-2025

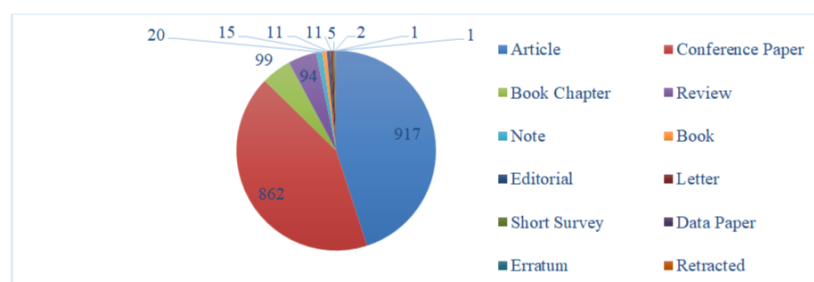


Figure 10. Types of articles by keyword search in the Scopus database “Generative AI; Education” for 2020-2025

Figures 9 and 10 clearly demonstrate the unprecedented growth of scientific interest in generative artificial intelligence in the field of education, which has quickly become one of the most rapidly developing areas of modern pedagogical science. While publication activity remained minimal in 2020-2022 (1-2 articles per year), reflecting the early stage of generative AI technology, a sharp jump was recorded in 2023 to 142 publications, coinciding with the widespread distribution of the GPT-3.5 and GPT-4 language models and the beginning of a global discussion on the transformation of the educational process under the influence of AI. In 2024, the number of works increased more than fivefold, reaching 722 publications, and in 2025, it reached 1,170, indicating exponential growth in scientific interest and the establishment of generative AI as a key research topic on a global scale. The structure of publications also confirms the intensity and maturity of the field: the majority are articles in peer-reviewed journals (917), followed by conference proceedings (862), reflecting the activity of both academic journals and professional scientific forums. A significant portion consists of reviews (99) and book chapters (94), indicating an accumulation of theoretical generalizations and attempts to systematize the rapidly growing body of research. The wide range of publication formats, from editorial materials to data documents, underscores the scale and diversity of scientific communication. Taken together, these data confirm that research on generative AI in education is at its peak, significantly influencing the rethinking of educational models, raising issues of pedagogical design, academic integrity, and ethics, and requiring further comprehensive analysis to develop scientifically sound approaches to integrating AI into the learning process.

To assess the extent to which issues related to the interconnection between education, digital skills, and artificial intelligence technologies are reflected in scientific discourse, a bibliometric analysis was performed using the keywords "Education; Digital skills; Artificial intelligence." This combination covers a wide range of studies focused on the digital competencies required by students and teachers, as well as the use of AI in teaching, assessment, learning management, and the development of digital literacy. Publication activity on these keywords is an indicator of the integration of digital skills into the modern educational agenda and demonstrates how rapidly interest in the development of digital competencies is growing against the backdrop of AI implementation.

The visual data presented in Figures 11 and 12 allow us to analyze both the growth dynamics of the number of publications for 2010-2025 and the structure of the types of scientific documents that form this field of research.

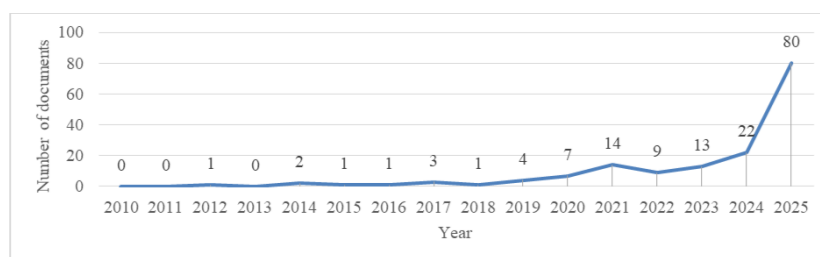


Figure 11. Number of articles found by searching for the keywords "Education; Digital skills; Artificial intelligence" in the Scopus database for 2010-2025

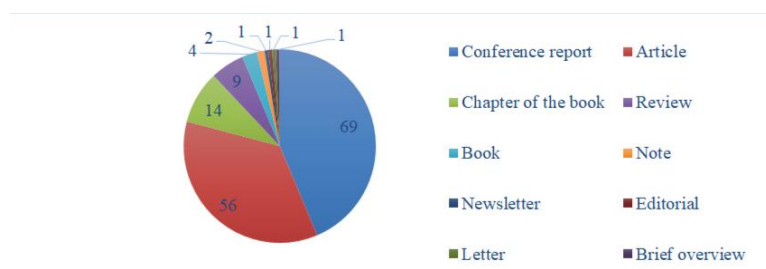


Figure 12. Types of articles by keyword search in the Scopus database "Education; Digital skills; Artificial intelligence" for 2010-2025

The data in Figures 11 and 12 demonstrate the steady and accelerating development of research dedicated to the formation of digital skills in the educational environment amid the active introduction of artificial intelligence technologies. In 2010-2016, publication activity remained at a minimum level (1-2 articles per year), reflecting the early stage of development of digital educational technologies and the lack of independent attention to digital skills as a subject of research. Since 2017, there has been a gradual increase in interest, which has intensified significantly in 2020-2021 (7 and 14 articles), coinciding with the rapid transition of educational systems to online formats and mass digitization. The most pronounced increase in publications is recorded in 2024-2025, when their number rises from 22 to 80, indicating a rapid expansion of scientific discourse and increased attention by researchers to the problem of preparing students to work in an AI-saturated digital environment. The structure of the documents also confirms the maturity and multifaceted nature of the field: the predominance of conference papers (69) and peer-reviewed articles (56) reflects a combination of intensive discussion of new results and the formation of a solid scientific base; a significant number of book chapters (14) and reviews (9) indicate the accumulation of theoretical and methodological foundations. Additional formats – books, notes, newsletters, editorial materials – demonstrate the expansion of scientific communication channels. Taken together, these data show that research on digital skills in the context of artificial intelligence is in a phase of active growth and institutional consolidation, becoming a key area of modern pedagogy and requiring further development of methodologies, learning models, and strategies for integrating AI into educational systems.

A bibliometric analysis of six search combinations conducted using the Scopus database for the period 2010-2025 revealed general and specific trends in the development of scientific research in the field of integrating artificial intelligence into education, digital literacy, and the formation of digital competencies. The diversity of search queries provided a multidimensional understanding of the dynamics of scientific discourse – from the general direction of “AI in higher education” to highly specialized topics such as adaptive learning, digital skills, and generative artificial intelligence.

The summary table systematizes the data obtained and allows for a visual comparison of the scale of scientific activity, the structure of publications, and the level of methodological maturity of various research areas (Table 2).

Table 2. Summary characteristics of publication activity by Scopus search combinations (2010-2025)

<i>№</i>	<i>Search combination</i>	<i>Analysis period</i>	<i>Number of publications</i>	<i>Peak of publications (year)</i>	<i>Dominant document types</i>	<i>Characteristics of the scientific field</i>
1	AI; Education; University	2010-2025	421	2025 (201 publication)	Conference proceedings (220), articles (167)	The broadest field; rapid growth in interest since 2021; establishment as a mature area of research.
2	Artificial intelligence; Digital competencies; Higher education	2020-2025	14	2025 (8 publications)	Articles (10), reports (2)	A narrow but growing field of research; to be established as an independent subject from 2023.
3	Learning using artificial intelligence; digital literacy	2010-2025	199	2025 (94 publications)	Reports (76), articles (69), reviews (22), book chapters (16)	A rapidly expanding field; emphasis on digital literacy and data skills development.
4	Adaptive learning; university students; artificial intelligence	2010-2025	11	2025 (5 publications)	Reports (8), articles (2)	The subject is in the early stages of development; research is mainly experimental and conceptual.

5	Generative AI; Education	2020-2025	2038	2025 (1170 publications)	Articles (917), reports (862), reviews (99), book chapters (94)	The most rapidly developing area; exponential growth following the emergence of ChatGPT and other models.
6	Education; Digital skills; Artificial intelligence	2010-2025	158	2025 (80 publications)	Reports (69), articles (56), book chapters (14), reviews (9)	A mature sector; steady growth due to digitalization and the updating of educational standards.

The summary data presented in Table 2 demonstrate significant differences in the scale, dynamics, and structure of scientific research on various combinations of keywords. The most ambitious and rapidly developing area is the study of generative artificial intelligence in education, where there has been exponential growth in publications since 2023. In contrast, research on adaptive learning is characterized by limited but steadily increasing popularity, reflecting the gradual introduction of adaptive technologies into educational processes.

Broad search queries such as “AI; Education; University” and “Education; Digital skills; Artificial intelligence” demonstrate both a high level of accumulated research and structural maturity: a significant proportion of these queries are articles and conference reports, which is a sign of active expansion of academic discussion. Narrow queries related to digital competencies and digital literacy show intense growth in publications over the past three years, confirming the relevance of the topic for the university sector.

Summarizing the results, we can conclude that the field of research devoted to the integration of AI into education shows a steady trend toward expansion and methodological enrichment. Various areas feature both established research priorities and promising, rapidly developing thematic niches, which underscores the need for further interdisciplinary research and systematic analysis of global experience.

3.2. Content analysis of scientific works 1. Research on AI and digital literacy among students A number of studies focus on conceptualizing and measuring the digital/AI literacy required by students in the context of the rapid adoption of AI. Laupichler et al. conduct a scoping review of research on AI literacy in higher and adult education, systematizing more than three dozen empirical and conceptual works and identifying four key areas: cognitive understanding of AI principles, critical attitude towards algorithms, practical skills, and ethical attitudes (Laupichler et al., 2022).

Yang et al., based on the PRISMA protocol, analyze a corpus of publications on AI literacy education programs for students and demonstrate that most courses focus on the instrumental use of AI, while critical digital literacy (issues of bias, transparency, and accountability) is covered much less extensively (Yang et al., 2025).

Biagini et al. emphasize in their systematic review of AI literacy that higher education programs remain fragmented: universities either introduce separate AI modules into ICT courses or develop specialized disciplines, but rarely build comprehensive trajectories for the formation of digital competencies that span several years of study (Biagini, 2025).

An important contribution to understanding the structure of competencies is made by Baskara, who proposes a conceptual framework for “digital literacy in the AI era,” which includes technical awareness of algorithms, data skills, critical thinking, and ethical reflection. The author shows that classical models of digital literacy (information and media literacy) do not sufficiently take into account the specifics of generative models and automated data processing (Baskara, 2025).

At the level of measuring digital literacy in the context of AI, the tool developed by Hwang et al., who developed and validated the “digital literacy in the AI era” scale for college students, is indicative. The study is based on quantitative methodology: a survey of several hundred students, exploratory and confirmatory factor analysis, Cronbach's alpha reliability assessment, and structural modeling. The

authors highlight the factors of technical skills, critical evaluation of algorithms, and understanding of the social implications of AI (Hwang et al., 2023).

Xiao shows, based on structural modeling (SEM), that a higher level of AI literacy among students in online courses is positively associated with their academic performance and self-efficacy, with the ability to critically interpret the responses of AI systems playing a mediating role (Xiao et al., 2024).

Taken together, these studies demonstrate that the first major area of research is the redefinition of digital literacy to include AI and the development of reliable measurement tools. Methodologically, systematic and scoping reviews dominate, as well as quantitative studies using surveys and factor/structural analysis.

2. Digital and AI competencies of university teachers At the same time, research is being conducted on the digital and AI competencies of teachers working in digital and blended learning environments. An article by Ng et al. analyzes how teachers' AI competencies are related to their ability to organize 21st-century learning. The study is based on a large-scale survey of teachers and modeling of structural relationships between digital skills, AI competencies, and skills such as critical thinking and collaborative learning among students (Ng et al., 2023).

Strutynska proposes a framework of AI competencies for educators, including pedagogical, technical, and ethical-legal components, based on an analysis of regulatory documents, existing digital competency frameworks (DigCompEdu, etc.), and the results of empirical studies on the implementation of AI in education (Strutynska et al., 2021).

From the perspective of university practice, the work of Mah et al. is interesting, where quantitative surveys and regression analysis show that even with a positive attitude of teachers towards AI, the intention to integrate it into courses is limited by low levels of AI literacy and a lack of institutional support, i.e., there is a gap between attitudes and actual practice (Mah et al., 2025).

These studies emphasize that the development of students' digital competencies is impossible without the parallel development of teachers' AI competencies, as well as without organizational support and appropriate policies in higher education institutions.

3. Generative AI and ChatGPT as a tool for developing digital skills The most rapidly developing area has been the assessment of the impact of generative AI (primarily ChatGPT) on student learning and digital skills. A large-scale meta-analysis by Wang & Fan shows that the use of ChatGPT in the educational process on average improves learning outcomes, enhances subjective perceptions of learning, and promotes the development of higher-level skills, although the effect is highly dependent on task design and the degree of pedagogical support (Wang & Fan, 2025).

Abdallah et al., in a 2025 systematic review based on the PRISMA protocol, analyze empirical studies of ChatGPT's use in higher education. The authors identify three clusters of effects: impact on academic performance, well-being, and collaboration. They note that when integrated competently, ChatGPT contributes to the development of information and media literacy, but at the same time raises questions about academic integrity and students' dependence on automated prompts (Abdallah et al., 2025).

Schei et al. scoping review covers empirical studies on students' perception and use of AI chatbots. The results show that students actively use chatbots to search for information, generate ideas, and reflect, but most often without sufficient skills to critically evaluate sources and understand the limitations of models, which poses challenges for the targeted development of digital and information literacy (Schei et al., 2024).

A number of quantitative studies focus directly on the student audience. Ravšelj et al., in a global online survey of university students, demonstrate that higher digital literacy and experience with AI are associated with more responsible, "partnership-based" use of ChatGPT – as a tool for independent learning rather than mechanical copying of answers (Ravšelj et al., 2025).

Al-Abdullatif et al. use the UTAUT model to analyze the factors that determine students' intention to use ChatGPT in their studies. Statistically significant predictors are expected usefulness, social influence, and digital self-efficacy; at the same time, the authors emphasize the need to develop critical

digital literacy in order to minimize the risks of uncritical trust in AI (Al-Abdullatif & Alsubaie, 2024).

Klimova examines students' attitudes toward the use of ChatGPT in academic activities based on a mixed methodology (survey + qualitative analysis of open-ended responses). Students see AI as a means of developing language and research skills, but some respondents point to a deterioration in the “depth” of their own thinking if tasks are based solely on content generation without reflection (Klimova et al., 2025).

Rajki et al. analyze the factors influencing students' use of AI tools (digital skills, academic motivation, discipline, course level) and show that the frequency of AI use is positively associated with academic performance only if students have developed independent work and digital critical thinking skills (Rajki et al., 2025).

Of particular note is the article by Honigsberg et al., which examines how the integration of generative AI into course assignments mediates the development of subject-specific and “GAI literacy.” The authors use qualitative methods (interviews, analysis of student work artifacts) and show that assignments involving comparing ChatGPT responses with expert sources significantly strengthen critical analysis and digital literacy skills, while purely reproductive assignments do not have this effect (Honigsberg et al., 2025).

The article by Ciampa et al. shows how the use of ChatGPT in digital literacy courses transforms the practices of working with text among adolescents and young adults: instead of linear reading and keyword searches, students move to dialogic interaction with information, which requires new pedagogical approaches to the formation of critical digital literacy (Ciampa et al., 2023). Thus, research on generative AI covers a wide range of methodologies: meta-analyses, systematic and scoping reviews, quantitative surveys using TAM/UTAUT models, mixed methods, and qualitative case studies. The overall conclusion is that ChatGPT and similar tools are becoming a powerful catalyst for the development of digital competencies, but the effect strongly depends on pedagogical design and the degree of emphasis on critical and ethical components.

4. AI, learning analytics, and digital skills development A separate cluster of studies examines learning analytics (LA) as a form of AI and data analysis applied to support student competency development. Kleimola & Leppisaari demonstrate in a case study how the use of LA in a university course allows for the identification of weaknesses in the development of “future competencies” (collaboration, problem solving, digital skills) and the adaptation of assignments to student levels. The methodology includes analyzing students' digital footprints in the LMS, visualizing data for teachers, and conducting follow-up interviews, making the study a typical example of mixed methods (Kleimola & Leppisaari, 2022).

Tsai et al. in a large-scale review of LA practices in European universities show that, despite rapid growth in research, the use of LA remains fragmented and is often limited to pilot projects at the level of individual teachers. Nevertheless, the authors emphasize the potential of LA for monitoring and developing students' digital skills, provided that there is an ethically sound data policy (Tsai et al., 2020).

Villalobos Díaz et al. analyze the mediating role of LA in the relationship between students' learning approaches and their academic performance at Latin American universities, using a quantitative structural equation model. The authors demonstrate that the use of LA panels increases students' awareness of their own learning strategies and contributes to the development of self-regulation and data handling skills, an important component of digital literacy.

Lai et al. view LA as a tool for bridging the gap between students' skills and labor market demands. Based on an analysis of large data sets on the academic performance and career aspirations of bachelor's degree students, the authors show that LA helps students identify gaps in their digital and professional skills and build individual trajectories, while helping universities adjust their curricula.

Finally, a review by Hernandez-de-Menéndez et al. summarizes the state of research on LA, noting a shift from purely descriptive analytics to predictive machine learning models designed to identify “at-risk” students early on and support their digital and learning competencies.

This block of work shows that AI in the form of LA is used primarily for the indirect development of digital competencies - through data visualization, self-regulation support, and career planning. Methodologically, case studies and quantitative research with analysis of large training data sets predominate.

5. *Synthesis reviews on AI in higher education* A number of articles serve as a “meta-framework” that embeds individual studies in the broader context of digital transformation in higher education. Adamakis et al., in a state-of-the-art review of AI in higher education, classify existing applications according to “pedagogical functions” (personalization, assessment, teacher support, academic management) and emphasize that studies directly targeting students' digital competencies currently constitute a smaller but rapidly growing share of publications.

Ocen et al. summarize the innovations, opportunities, and challenges of AI in higher education, paying particular attention to issues of ethics, academic integrity, and digital inequality. The authors note that without targeted digital inclusion programs, AI tools can widen the gap between students with different levels of digital skills.

In a meta-systematic review of more than a hundred studies on AI in higher education, Bond et al. highlight the lack of research with high methodological rigor (randomized experiments, advanced statistical analysis), especially in terms of assessing the long-term impact of AI on students' digital competencies.

Schmidt et al. in their mixed-method study “Integrating artificial intelligence in higher education” analyze the perception of AI by faculty and administrators, identifying key strategies for academic innovation - from local pilots to systemic transformation of curricula. One of the conclusions is the need to include AI and digital literacy in university professional development strategies .

Aguado-García, using a bibliometric approach, shows that in recent years, the focus of AI in higher education has shifted from purely technological aspects to issues of pedagogy, digital skills, and ethics, confirming the relevance of your focus on digital competencies.

A review of more than 28 articles from peer-reviewed journals indexed in Scopus (Q1-Q4) showed that research on the application of artificial intelligence technologies in the formation of digital literacy and digital competencies in higher education focuses on several consistent thematic areas. For clarity, these areas are aggregated in a comparative table that reflects key authors, target groups, prevailing methodological approaches, and main results (Table 3).

Table 3. Main areas of research on AI and digital competencies in higher education

№	The direction of research	Key authors and works (approximately)	Target audience (research participants)	Prevailing methodologies	Main conclusions and accents
1	Conceptualizing and measuring students' digital/AI literacy	Baskara (2025); Hwang et al. (2023); Xiao (2024); Laupichler et al. (2023)	College and university students; sometimes adult students	Quantitative surveys; development and validation of scales; factor and structural analysis; scoping and systematic reviews	New models of digital and AI literacy are being formulated, including technical skills, a critical attitude to algorithms, and an understanding of the ethics and social consequences of AI. Reliable tools for measuring digital competencies in the "AI era" are being created.
2	Development of AI competencies of teachers and institutional policy	Ng et al. (2023); Strutynska (2021); Mah et al. (2025)	University professors, teachers of digital and mixed courses, sometimes the administration	Quantitative surveys (SEM, regression); conceptual and framework articles; analysis of regulatory documents and	It is shown that teachers' digital and AI competencies have a direct impact on the formation of students' digital skills. Barriers have been identified: insufficient teacher training, lack of institutional support and clear strategies for implementing AI. Frameworks of

				existing competence frameworks	competencies and recommendations for policy in higher education institutions are proposed.
3	<i>Generative AI and chatbots (ChatGPT, etc.) as a medium for the formation of digital skills</i>	Wang & Fan (2025); Abdallah et al. (2025); Schei et al. (2024); Honigsberg et al. (2025); Ravšelj et al. (2025); Al-Abdullatif et al. (2024); Klimova (2025); Rajki et al. (2025); Ciampa et al. (2023)	Undergraduate and graduate students; sometimes mixed samples of students and teachers	Meta-analyses and systematic reviews (PRISMA); large-scale surveys (TAM/UTAUT); mixed methods (survey + interview/content analysis); case studies of courses	Generative AI can enhance learning outcomes, motivation, and the development of digital literacy (information retrieval, processing, and criticism), but only with meaningful pedagogical design. The risks have been identified: academic dishonesty, dependence on hints, lack of critical thinking. The need for a regulatory and ethical framework for the use of ChatGPT and similar systems is noted.
4	<i>Learning analytics and big educational data analysis</i>	Kleimola & Leppisaari (2022); Tsai et al. (2020); Díaz et al. (2024); Lai et al. (2025); Hernández-de-Menéndez et al. (2020)	University students (LMS data, academic performance journal); sometimes teachers as users of LA panels	Case study; analysis of digital footprints of students; predictive modeling and machine learning; quantitative research (SEM, regression)	LA is used to monitor learning activity, identify "risky" students early, and support self-regulation and career planning. It indirectly promotes the development of digital competencies (working with data, self-assessment, digital reflection), but requires a well-thought-out data privacy policy and digital ethics.
5	<i>Synthesis reviews and strategic frameworks of AI in higher education</i>	Adamakis et al. (2025); Ocen et al. (2025); Bond et al. (2024); Schmidt et al. (2025); Aguado-García (2025)	System level: higher education systems, universities, teachers and students (as elements of the digital ecosystem)	Meta-reviews, bibliometric analysis, conceptual articles; mixed methodologies (surveys + document analysis)	There is a shift from technological enthusiasm to more balanced models of AI integration: attention is shifting to digital competencies, ethics, inclusion, and human agency. There is a lack of rigorous empirical research on the long-term impact of AI on the quality of graduate education, especially in the context of developing countries.

3.3. Conceptual Framework for Understanding the Pedagogical Impact of AI on Digital Competency Development

Building on the results of the systematic literature review, this study proposes an analytical framework conceptualizing artificial intelligence as a multi-level pedagogical factor shaping the development of students' digital competencies. Contemporary research increasingly demonstrates that AI does not influence learning outcomes directly; instead, its pedagogical effects are mediated through several layers of educational systems, institutional policies, instructional decisions, and students' own learning practices. However, previous studies rarely integrate these layers into a single explanatory model, which limits the understanding of how AI-driven tools translate into measurable competencies and human capital outcomes.

To address this gap, the framework presented in Figure 13 synthesizes insights from the five thematic clusters identified in the review: AI/digital literacy, teachers' AI competencies, generative AI tools, learning analytics, and strategic models of AI integration in higher education. The model distinguishes four structural levels (system, institutional, pedagogical, and individual) and connects them with a horizontal causal chain that explains how AI tools embedded in learning environments are transformed into digital competencies and broader human capital outcomes.

This framework helps conceptualize AI not merely as a technological innovation, but as a structured pedagogical ecosystem requiring alignment between national strategies, university policies, instructional design, and student agency. The figure below visualizes this multi-level process.

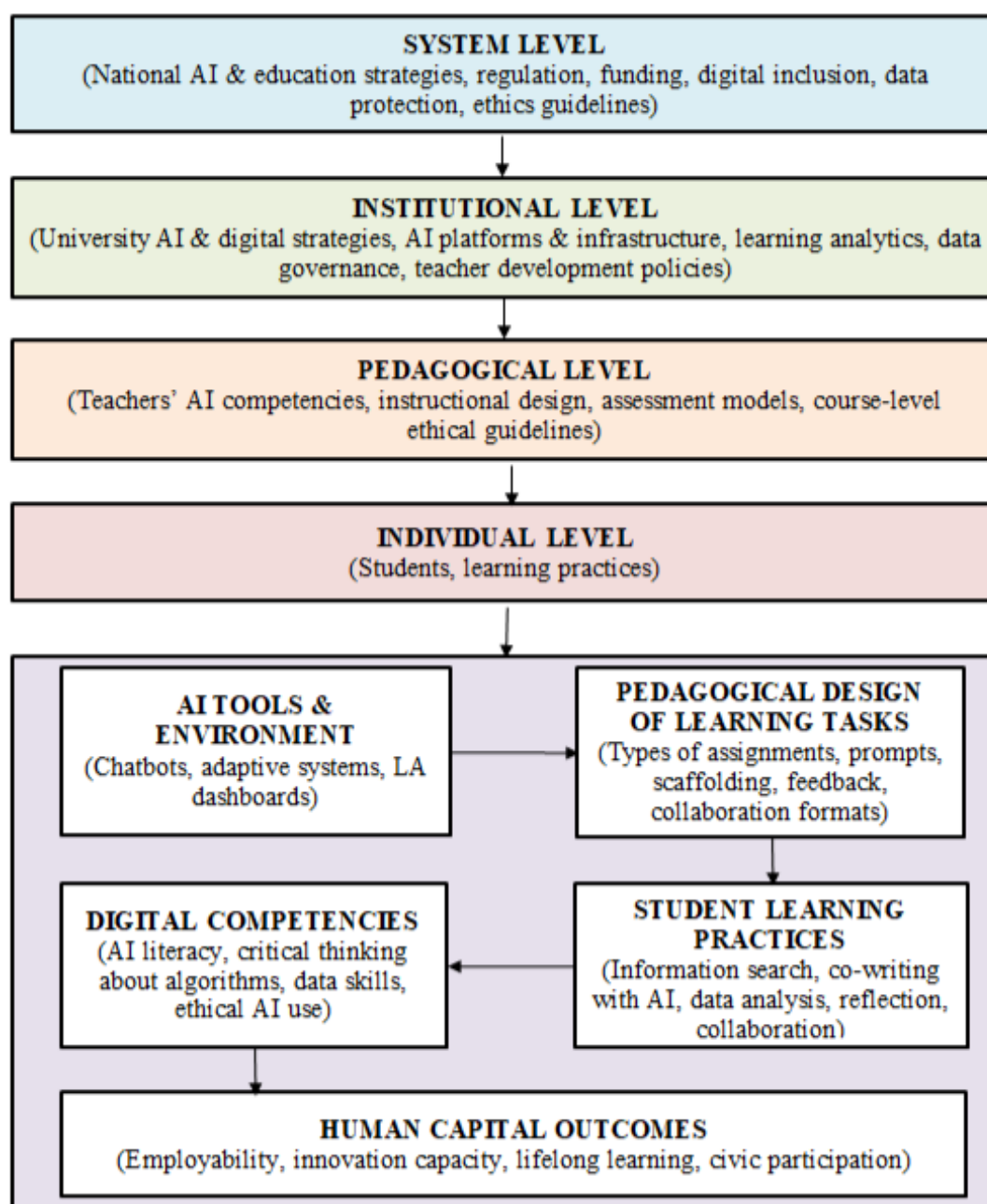


Figure 13. Multi-level analytical framework of AI as a pedagogical factor in the development of students' digital competencies

The analytical framework in Figure 13 demonstrates that the development of students' digital competencies in the AI era is a multi-layered and interdependent process. The upper levels – system and institutional – form the structural conditions that enable or constrain the pedagogical use of AI. National strategies, digital inclusion policies, and ethical regulations determine access to AI technologies, while universities operationalize these requirements through AI platforms, data governance mechanisms, learning analytics systems, and teacher development programs.

The pedagogical level acts as the core mediating mechanism. Teachers' AI competencies, together with instructional design choices – such as the types of assignments, scaffolding, feedback formats, and the integration of generative AI or analytics dashboards – shape how students actually interact with AI tools. Without pedagogical mediation, AI remains a purely technical resource and fails to support deep learning or the formation of critical digital skills.

The individual level captures the micro-processes through which students transform AI interactions into competencies. Learning practices such as information search, co-writing with generative models, data interpretation, reflection, or collaborative problem-solving serve as the immediate channels through which digital competencies develop. These competencies include AI literacy, critical thinking about algorithms, ethical AI use, and the ability to work with data – core skills demanded by the modern labor market.

Finally, the framework situates digital competencies within a broader context of human capital outcomes, including employability, innovation capacity, lifelong learning readiness, and civic participation. This emphasizes that the pedagogical use of AI is not only an instructional matter, but also a strategic component of human capital development at national and institutional levels.

Overall, the framework clarifies why fragmented, tool-focused approaches to AI implementation often fail: sustainable development of digital competencies emerges only when all four levels-systemic, institutional, pedagogical, and individual - are aligned. The model therefore offers a conceptual basis for designing AI-enhanced curricula, developing teacher training systems, and shaping evidence-based digital transformation policies in higher education.

Conclusions. A systematic review of contemporary research on the pedagogical potential of artificial intelligence in developing students' digital competencies allows us to draw a number of general and conceptually significant conclusions that reflect the state, possibilities, and limitations of the field under study.

First, an analysis of publication activity shows that the topic of AI integration in higher education is experiencing a phase of rapid growth, especially after 2020 and the emergence of generative models. However, the quantitative growth in publications is not always accompanied by methodological depth: many studies assess short-term effects without offering long-term models for the formation of digital competencies. Despite the growing number of works, the depth of operationalization of the concepts of “digital competencies” and “AI literacy” remains uneven, which makes it difficult to compare results.

Secondly, the review showed that AI has significant pedagogical potential, but its impact on students' digital competencies is ambiguous and depends on the conditions of use. Generative models and intelligent systems are indeed capable of supporting the development of analytical, data processing, critical thinking, and digital reflection skills, but only if there is a well-thought-out pedagogical design. Without methodological support, AI can lead to superficial learning, reduced cognitive effort, and the replacement of independent work with automated solutions. Thus, AI alone does not guarantee the development of digital competencies – the role of the teacher, the organization of the learning environment, and the ethical framework are critically important.

Thirdly, research emphasizes that the development of students' digital and AI competencies is impossible without the accompanying development of teachers' competencies. It is teachers who determine how AI will be integrated into the learning process, which tasks will develop digital literacy, and which, on the contrary, will contribute to dependence on automated prompts. Studies show that a lack of teacher training, insufficient institutional support, and the absence of strategic policies limit the educational impact of AI.

Fourth, learning analytics demonstrates high potential for the indirect development of digital competencies. Using learning activity data enhances self-regulation, the ability to interpret information, and analyze one's own learning strategies-key components of digital literacy. However, these benefits are realized only through adherence to ethical data processing standards, transparency of algorithms, and accessibility of analytical tools for students.

Fifth, the systematization of the results revealed a key research gap (GAP): most existing studies consider AI technologies as local tools, but rarely as a component of a holistic model for developing digital competencies at universities. Insufficient research has been conducted on:

- the long-term effects of AI use on the development of digital competencies;
- the impact of AI in different institutional and national contexts, especially in developing countries;
- the integration of AI into curricula and university strategy at the systemic level;

- the balance between automation and the development of human agency in learning.

Finally, the review's findings demonstrate that AI should be viewed not only as a technological innovation but also as a pedagogical transformation, requiring comprehensive changes – from teacher training to curriculum revisions and the formulation of ethical regulations. The pedagogical potential of artificial intelligence can significantly enhance the development of students' digital competencies, but realizing this potential requires a strategic, scientifically sound, and pedagogically sound approach.

Taken together, this study demonstrates that developing digital competencies in the AI era is a multi-layered process requiring interdisciplinary analysis, experimental verification, and institutional support. The findings can serve as a foundation for reforming educational programs, developing national policies for the digital transformation of higher education, and designing future research aimed at deeply understanding the role of AI in human capital development.

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ЦИФРЛЫҚ БІЛІМ БЕРУ ТЕХНОЛОГИЯЛАРЫ НЕГІЗІНДЕ СТУДЕНТТЕРГЕ ҚАЗАҚ ТІЛІН ИНТЕГРАЦИЯЛЫҚ ОҚЫТУДЫҢ СИНЕРГЕТИКАЛЫҚ МОДЕЛІ

Аңдатпа

Мақалада цифрлық білім беру технологияларын қолдану негізінде қазақ тілі экспрессивтік стилистикасын интеграциялық оқытудың ғылыми-әдіснамалық негіздері қарастырылады. Зерттеудің мақсаты – цифрлық білім беру технологиялары жағдайында қазақ тілі экспрессивтік стилистикасын пәнаралық консолидациялау нәтижелерін синергетикалық модельдеудің қажеттілігі мен мүмкіндіктерін анықтау. Зерттеу барысында ғылыми әдебиеттерді талдау, салыстыру, жүйелеу, модельдеу, индукция, дедукция және синергетикалық тәсіл қолданылды. Қазақ тілі экспрессивтік стилистикасын оқытудың интеграциялық парадигмалары жүйеленіп, тілдік құбылыстардың цифрлық білім беру ортасындағы өзара байланысы талданды. Интерактивті оқыту әдістері, мультимедиялық ресурстар, цифрлық платформалар және жасанды интеллект мүмкіндіктерін пайдалану арқылы білім алушылардың тілдік, коммуникативтік және цифрлық құзыреттерін дамыту жолдары айқындалды. Зерттеу нәтижесінде қазақ тілінің экспрессивтік стилистикасын цифрлық білім беру технологиялары негізінде интеграциялық оқытудың синергетикалық моделі әзірленіп, оның құрылымдық компоненттері, педагогикалық шарттары және ғылыми-әдістемелік негіздері ұсынылды. Ұсынылған модель білім алушылардың танымдық белсенділігін арттыруға, пәнаралық байланысты күшейтуге, коммуникативтік құзыреттілігін дамытуға және қазақ тілін оқытудың тиімділігін арттыруға мүмкіндік береді.

Түйін сөздер: педагогика, заманауи білім, қазақ тілі, цифрлық технология, пәнаралық консолидация, интеграциялық оқыту.

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СИНЕРГЕТИЧЕСКАЯ МОДЕЛЬ ИНТЕГРИРОВАННОГО ОБУЧЕНИЯ СТУДЕНТОВ КАЗАХСКОМУ ЯЗЫКУ С ИСПОЛЬЗОВАНИЕМ ЦИФРОВЫХ ОБРАЗОВАТЕЛЬНЫХ ТЕХНОЛОГИЙ

Аннотация

В статье рассматриваются научно-методологические основы интегрированного обучения выразительной стилистике казахского языка на основе применения цифровых образовательных технологий. Цель исследования заключается в определении необходимости и возможностей синергетического моделирования результатов междисциплинарной консолидации выразительной стилистики казахского языка в условиях цифровых образовательных технологий. В ходе исследования использованы методы анализа научной литературы, сравнения,