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ARTIFICIAL INTELLIGENCE IN EDUCATION: THEORETICAL FOUNDATIONS, HISTORICAL DEVELOPMENT, AND PROSPECTS

Abstract

This article addresses the use of artificial intelligence in education. As a subject of pedagogical research, artificial intelligence has its own conceptual framework, structure, and a history of development spanning more than half a century. There are also limits to the application of AI in education and constraints imposed on these processes. It has been noted that, since 2022, generative language models have gradually but rapidly been incorporated into the practice of educators at various levels of education. Artificial intelligence services began to be used even before the relevant institutional rules were established, methodological recommendations were developed, and professional development programs for educators were organized. The aim of the study is to substantiate the interpretation of the concept of “artificial intelligence in education,” to identify the stages of AI development, and to explore the prospects for its integration into the education system, taking into account the results of a survey of teachers. The study employs a comparative analysis of definitions, the historical-pedagogical method, an analysis of regulatory documents from the European Union

and UNESCO, and a survey of academic and teaching staff at Ukrainian higher education institutions (31 questions in six sections). Artificial intelligence in education is proposed to be broadly defined as a group of software tools that, based on relevant services, perform operations such as forecasting, individualization, assessment, and the generation of instructional materials, as well as carrying out specific functions to support the educational process without replacing the teacher. In the history of the development and implementation of AI elements in education, five stages have been identified, spanning periods from the use of programmed computerized instruction to the use of generative artificial intelligence services with varying functionality. The prospects for the further integration of artificial intelligence services into the educational process are primarily linked to changes in the assessment system and a shift in emphasis from evaluating the final results of tasks to the process itself, the development of institution-specific policies for AI application in educational institutions, and the institutionalization of training for both future and current teachers in the pedagogically sound use of AI services.

Keywords: artificial intelligence in education; generative artificial intelligence; academic integrity; strengthening the foundational aspects of professional training; higher education.

Statement of the Problem. The process of higher education reform around the world, as well as in Ukraine, is becoming an ongoing phenomenon. It has significantly accelerated over the past four years with the advent of open access to generative language models (2022 – ChatGPT). Students in higher education and high school began actively using these models to complete assignments for practical and laboratory work, write literary works, and so on. After some time, educators also began using content-generation services. Almost no one paid attention to the need to credit artificial intelligence services as the authors of the generated materials.

Scientific understanding of the consequences of the thoughtless use of generative AI services in higher education institutions lagged significantly behind actual practices. Participants in the educational process quite often used AI services without having any idea about how they work, their limitations, potential "hallucinations," or the use of outdated and unreliable data.

There is a need to study the fundamental principles of AI use, without focusing on its environments, which change every six months. A similar situation already occurred in high school computer science in the early 2000s [23].

The topic of studying artificial intelligence systems (Intelligent Systems) first appeared in the curriculum for the general education school subject "Computer Science" in 1996. However, the practical use of AI services never materialized, and so when the widespread use of large language models began in 2022, the Ministry of Education and Science did not issue recommendations on the use of AI in general secondary and higher education institutions until 2024 [17] and 2025 [18].

Consequently, there is currently a contradiction between the need for a scientifically sound and pedagogically balanced system for integrating AI into professional training and the lack of practical, experimentally validated methods for applying AI for educational and scientific purposes, as well as the absence of ethical and legal standards for such application formulated at the institutional level.

Analysis of Recent Studies and Publications. Researchers from various countries have investigated the nature and components of AI, as well as its application in education and scientific research:

– philosophical, ethical, and technical issues related to AI: Alan Mathison Turing [24], John McCarthy et al. [14], S. Russell (Stuart Russell) and P. Norvig (Peter Norvig) [21], and others;

– classification of technologies for using AI in education and interpretations of this concept in pedagogy: W. Holmes, M. Bialik, C. Fadel [7], T. K. F. Chiu et al. [5], M. Bond et al. [3], and others;

– historical aspects of AI application in education and issues regarding the effectiveness of computer-based learning systems: J. R. Carbonell [4], B. S. Bloom [2], S. Doroudi [6], and others;

– specific features of using LLM models in education, associated risks and limitations, and technologies for detecting generated text: E. Kasneci et al. [10], C. R. Jones, B. K. Bergen [9], W. Liang et al. [12], and others;

– aspects of developing educators' digital competence in the field of AI: N. Morze et al. [19], I. Vorotnikova, O. Dzyabenko, and N. Morze [25], D. K. Mah, N. Groß [13], and others;

– regulatory frameworks for the use of AI in education—documents from UNESCO [15, 16], the European Union [20], the Ministry of Education and Science of Ukraine [17], [18], and others.

It is worth highlighting the comprehensive review of scientific publications on the use of AI in education [3], conducted by M. Bond and co-authors. They synthesized 66 publications and found that researchers most often focus on the challenges of using adaptive systems and individualizing learning, while issues of ethics and methodology regarding the use of AI in higher education remain under-researched.

In the scholarly works of Ukrainian researchers, the issue of fundamental—as opposed to instrumental—teacher training remains understudied.

Purpose of the Article. The purpose of this study is to substantiate the interpretation of the concept of "artificial intelligence in education," to identify the stages of AI development, and to explore the prospects for its integration into the education system, taking into account the results of a survey of teachers.

Presentation of the Main Research Material

1. The Concept of "Artificial Intelligence" and Approaches to Its Interpretation

In science, there are many approaches to defining the concept of "artificial intelligence." The study of artificial intelligence in computer science, philosophy, psychology, pedagogy, engineering, and medicine yields different definitions

depending on the research objective. Given the existence of such a large number of definitions of the concept of AI, it can be said that there is no precise, unified, rigorous, or universally accepted definition. This is similar to the situation with the concept of "information" in computer science, which, according to many scientists, cannot be clearly and universally defined and described [23].

For a long time, the scientific community supported the proposal by A. M. Turing, who in 1950 suggested moving beyond philosophical debates on the question "Can a machine think?" to testing the cognitive capabilities of artificial intelligence based on its ability to engage in dialogue with a human. If the judge (or judges) monitoring the exchange of messages cannot determine which of the interlocutors is a human and which is a machine, then one can conclude that its intelligence is "genuine" [24].

The term "artificial intelligence" itself was proposed by J. McCarthy, M. L. Minsky, N. Rochester, and C. E. Shannon during preparations for the 1955 Dartmouth Summer Research Project. The authors proceeded from the assumption that any aspect of learning or intelligence can be described with sufficient precision to be modeled by a machine [14].

For a long time, no machine was able to pass the test proposed by A. M. Turing. It was not until 2025 that C. R. Jones and B. K. Bergen determined that the GPT-4.5 model had successfully passed this test. The judges recognized this model as a "human" in 73% of cases—much more often than the actual humans who participated in the experiment [9]. The judges focused primarily on speech style and socio-emotional characteristics, and only to a limited extent on the system's pedagogical suitability.

Pedagogy complements the technical definitions of AI used in the relevant sciences by addressing the use of artificial intelligence in the educational process. A comparison of the main approaches is presented in Table 1.

Table 1

Approaches to Defining the Concept of «Artificial Intelligence»

Approach (author, year)	Method of definition	Criterion
Operational (A. M. Turing, 1950)	Simulation game	The impossibility of distinguishing AI from a human in dialogue
Engineering (J. McCarthy et al., 1955)	Intelligence modeling program	The ability to formally describe mental activity
Philosophical (J. R. Searle et al., 1980)	Weak / strong AI	The presence or absence of understanding
System-forming (S. Russell, P. Norvig, 2020)	Four paradigms: thinking / acting like a human / rationally	The type of rationality of the system
Applied (T. Baker, L. Smith, 2019)	Narrow / general AI	The range of problems the system solves
Pedagogical (W. Holmes, M. Bialik, C. Fadel, 2019)	Learning with AI, about AI, for life in an AI-driven world	Function in the educational process

The table was created by the authors based on an analysis of the following sources: [1, 7, 14, 21, 22, 24]

It is advisable to view AI in education not as a separate technology, but as a general term for an entire class of systems.

The works of Ukrainian educators and researchers are largely focused on studying the development of competencies among teaching and research staff in the field of using artificial intelligence services in education. The works of N. V. Morze and co-authors [19] are devoted to this topic. I. Vorotnikova and her co-authors investigate the specifics of using AI services as a means of individualizing learning, which requires special training for educators [25]. Unlike their foreign counterparts, Ukrainian researchers are not actively exploring certain ideas regarding the classification and use of AI in education. For example, the distinction between weak and strong, narrow and

general AI is not addressed. As a result, Ukrainian educational literature quite often equates AI with machine learning, chatbots, or learning analytics.

2. Stages of Artificial Intelligence Development in Education

The methodology for using artificial intelligence services in education is based on the practical application of computer technologies in education. The first attempts to scientifically justify and experimentally test the possibilities of integrating computer systems into educational systems were made in the United States in the 1950s and 1960s. One example of such use is the University of Illinois' PLATO system, which implemented programmed learning based on the "stimulus–response–reinforcement" model. The subsequent stages of development in the use of computer technologies in education leading up to the stage of artificial intelligence are presented in Table 2.

S. Doroudi notes that the current stage of AI use in education should not be viewed as something new and cautions against interpreting this stage as one that is unrelated to the previous development of computer-based learning systems. This development spans more than half a century, and the current stage is the most advanced to date, though not the first [6]. While generally agreeing with this, it is worth pointing out one significant difference.

This gives rise to the main methodological problem of the current stage: the pedagogical quality of the result obtained depends not so much on the system developer as on the user's competence.

The development of AI in education in Ukraine followed a different path. The starting point here was not the creation of AI research laboratories, but the introduction in 1985 of the course "Fundamentals of Computer Science and Computing" in general education schools. However, AI-related topics began to be addressed in school education during the 1990s–2010s as part of the informatization of education. In contrast, the response to the emergence of generative AI was virtually in sync with the global trend: a draft of instructional and methodological recommendations for general

secondary education institutions was published in 2024 [17], and recommendations for higher education institutions followed in 2025 [18].

Table 2

Stages of the Use of Computer Technologies and AI in Education

Period	Dominant Paradigm	Characteristic Systems	Adaptation Mechanism
1950s–1960s	Computer-Programmed Instruction	PLATO	Rigid linear or branching script
1970s.	Emergence of Intelligent Tutoring Systems	SCHOLAR, SOPHIE	Symbolic models of the subject domain and the learner
1980s–1990s	Cognitive architectures	LISP Tutor, Cognitive Tutors	Tracking the mastery of individual skills
2000s–2010s	Adaptive platforms, learning analytics	ALEKS, Knewton, MOOC platforms	Statistical patterns in large datasets
Since 2022	Generative AI	ChatGPT, Gemini, Claude, etc.	General language model and pedagogical constraints

The table was created by the authors based on an analysis of the following sources: [6, 8, 10]

3. Technological Features of the Current Stage and the Issue of Academic Integrity

As already noted, the pedagogical quality of a generative model's output depends to a large extent on the user. Therefore, one of the key components of a teacher's competence is the ability to formulate prompts for the model. Prompt engineering is often perceived as a set of practical techniques, but it has a very specific scientific foundation. J. Wei and co-authors demonstrated that including intermediate reasoning steps (chain-of-thought) in examples significantly improves large models' ability to solve arithmetic and logical problems [26]. T. Kojima and his co-authors found that even adding the phrase "let's consider this step by step" to a query yields a noticeable effect [11]. In other words, the requirement to explain the solution process is not only a pedagogical but also a technical technique for improving the quality of the answer.

From the perspective of supporting faculty in their research activities, services that utilize RAG (retrieval-augmented generation) technology are particularly important. These services (Elicit, Consensus, Scite, Gemini Notebook) operate on verified collections of scientific documents created by the user or on databases from Scopus or WoS. The risk of inaccurate data is significantly reduced. However, verifying each source remains essential

4. Readiness of Higher Education Faculty to Use Artificial Intelligence

To assess the level of awareness, experience, and readiness of higher education faculty to use AI in their professional activities, an anonymous questionnaire titled "Artificial Intelligence in the Training of Higher Education Specialists" was developed. The questionnaire contains 31 questions grouped into six sections: the first covers professional background; the second, knowledge and experience with AI; the third, competencies and readiness; the fourth, attitudes toward the impact of AI on education; the fifth, risks and barriers; and the sixth, educational needs and preferred learning formats. The survey was conducted among participants in professional development courses for research and teaching staff at the Oleksandr Dovzhenko Hlukhiv National Pedagogical University. The survey took place from October 5 to October 20, 2026, with 92 faculty members from 30 higher education institutions participating. The distribution of participants by position is as follows: teaching assistants and trainee instructors—11 people; senior instructors—14 people; associate professors—46 people; professors—8 people; department chairs—6 people; others—7 people.

The questionnaires were analyzed as follows: for ordinal scale data, medians and response proportions were calculated; for continuous variables, means and standard deviations were calculated. The relationship between self-assessed competencies and the frequency of AI service use was determined using Spearman's rank correlation coefficient.

The frequency of AI service use by survey participants is presented in Table 3.

Table 3

Frequency of Generative AI Use by Higher Education Faculty (n = 92)

Frequency of Use	Number of Responses	Percentage, %
Daily	25	27
Weekly	35	37,8
Monthly	10	10,8
Tried it a few times	22	24,3
Never	0	0

Source: results of a survey conducted by the authors

As shown in Table 3, approximately 65% of respondents use generative AI weekly or daily. For comparison: according to [25], in May 2024, 42.4% of higher education faculty members used such tools in their professional activities. AI is most often used to prepare lectures and instructional materials, develop practical assignments and case studies, and create tests and assessment tools; it is least often used to grade and provide feedback on students' work or to prepare individual assignments. This distribution is consistent with the findings of [13], according to which faculty members at German universities most frequently used AI for planning and preparing classes.

The results of a survey of students regarding factors that hinder the use of AI in education are presented in the diagram (Fig. 1).

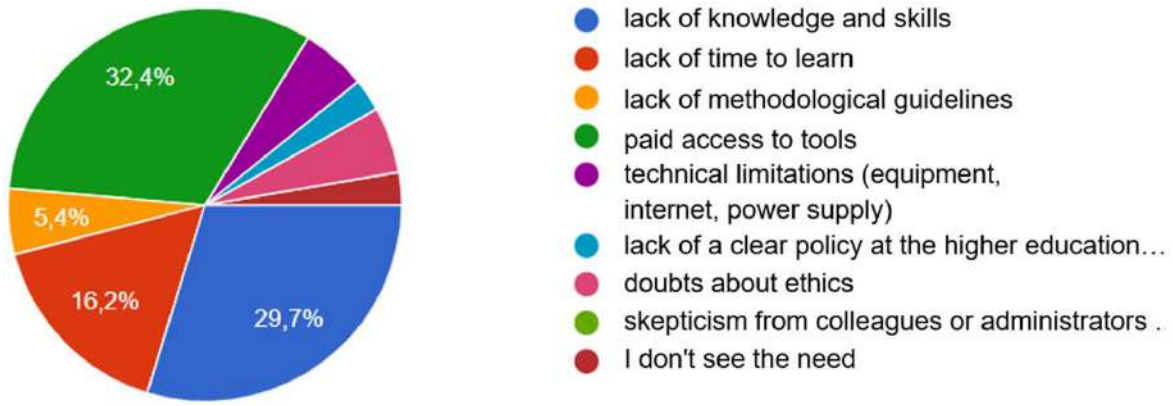


Fig. 1. Distribution of respondents' answers to the question «What prevents you from using AI more extensively?»

Respondents believe that the main challenges in mastering AI services are the cost of accessing AI tools, a lack of knowledge and skills, and a lack of time to learn how to use the services. This correlates with the main expectations for completing the course—acquiring the skills to ethically and effectively integrate AI tools into the educational process.

5. Prospects for Implementing Artificial Intelligence in Professional Training

A synthesis of the results of the theoretical analysis and the survey allows us to identify the main challenges of AI implementation and the approaches to addressing them. At the pedagogical level, the key is not to oppose the use of AI tools, but to change the content and formats of learning tasks. At the regulatory level, modern regulatory documents should be implemented into educational practice.

Questions regarding the long-term impact of AI on learning outcomes remain open: whether skills developed using AI can be transferred to other situations, how student motivation changes, and how AI influences the development of independent thinking [4]. Answers to these questions require further research.

Conclusions

The present study provides grounds for the following conclusions.

1. AI in education should be viewed as a general term for a class of specialized software systems that perform functions such as forecasting, personalization, intelligent learning support, and the creation of educational materials, and are designed to support—rather than replace—the participants in the educational process.

2. The development of AI in education is not a discontinuity but a continuous process—from programmed learning through intelligent learning systems and adaptive platforms to generative models.

3. Tools for detecting generated text do not provide reliable evidence of academic misconduct; therefore, the assessment of the process of completing academic assignments should form the basis of relevant policies at higher education institutions.

4. The results of a survey of higher education faculty members revealed the need for systematic training on the use of AI in education.

Based on these results, the following areas for further research can be identified:

– the development and testing of a professional development program for higher education faculty on the use of AI, focused on addressing identified competency gaps and studying the principles of how AI systems work.

References

1. Baker, T., & Smith, L. (2019). Educ-AI-tion rebooted? Exploring the future of artificial intelligence in schools and colleges. Nesta.

2. Bloom, B. S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. Educational Researcher, 13(6), 4–16. https://doi.org/10.3102/0013189X013006004

3. Bond, M., Khosravi, H., De Laat, M., Bergdahl, N., Negrea, V., Oxley, E., Pham, P., Chong, S. W., & Siemens, G. (2024). A meta systematic review of artificial intelligence in higher education: A call for increased ethics, collaboration, and rigour. International Journal of Educational Technology in Higher Education, 21, Article 4. https://doi.org/10.1186/s41239-023-00436-z

4. Carbonell, J. R. (1970). AI in CAI: An artificial-intelligence approach to computer-assisted instruction. IEEE Transactions on Man-Machine Systems, 11(4), 190–202. https://doi.org/10.1109/TMMS.1970.299942

5. Chiu, T. K. F., Xia, Q., Zhou, X., Chai, C. S., & Cheng, M. (2023). Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. Computers and Education: Artificial Intelligence, 4, Article 100118. https://doi.org/10.1016/j.caeai.2022.100118

6. Doroudi, S. (2023). The intertwined histories of artificial intelligence and education. International Journal of Artificial Intelligence in Education, 33(4), 885–928. https://doi.org/10.1007/s40593-022-00313-2

7. Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign.

8. Jones, C. R., & Bergen, B. K. (2024). Does GPT-4 pass the Turing test? In Proceedings of the 2024 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies (Vol. 1, pp. 5183–5210). https://doi.org/10.18653/v1/2024.naacl-long.290

9. Jones, C. R., & Bergen, B. K. (2025). Large language models pass the Turing test (arXiv:2503.23674). arXiv. https://doi.org/10.48550/arXiv.2503.23674

10. Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., … Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. Learning and Individual Differences, 103, Article 102274. https://doi.org/10.1016/j.lindif.2023.102274

11. Kojima, T., Gu, S. S., Reid, M., Matsuo, Y., & Iwasawa, Y. (2022). Large language models are zero-shot reasoners. Advances in Neural Information Processing Systems, 35, 22199–22213.

12. Liang, W., Yuksekgonul, M., Mao, Y., Wu, E., & Zou, J. (2023). GPT detectors are biased against non-native English writers. Patterns, 4(7), Article 100779. https://doi.org/10.1016/j.patter.2023.100779

13. Mah, D.-K., & Groß, N. (2024). Artificial intelligence in higher education: Exploring faculty use, self-efficacy, distinct profiles, and professional development needs. International Journal of Educational Technology in Higher Education, 21, Article 58. https://doi.org/10.1186/s41239-024-00490-1

14. McCarthy, J., Minsky, M. L., Rochester, N., & Shannon, C. E. (2006). A proposal for the Dartmouth summer research project on artificial intelligence, August 31, 1955. AI Magazine, 27(4), 12–14.

15. Miao, F., & Holmes, W. (2023). Guidance for generative AI in education and research. UNESCO. https://doi.org/10.54675/EWZM9535

16. Miao, F., & Shiohira, K. (2024). AI competency framework for students. UNESCO. https://doi.org/10.54675/JKJB9835

17. Ministry of Education and Science of Ukraine. (2024). Instruktyvno-metodychni rekomendatsii shchodo zaprovadzhennia ta vykorystannia tekhnolohii shtuchnoho intelektu v zakladakh zahalnoi serednoi osvity: Proiekt [Instructional and methodological recommendations on the introduction and use of artificial intelligence technologies in general secondary education institutions: Draft]. https://mon.gov.ua/static-objects/mon/sites/1/news/2024/05/21/Instruktyvno.metodychni.rekomendatsiyi.shchodo.SHI.v.ZZSO-22.05.2024.pdf

18. Ministry of Education and Science of Ukraine, & Ministry of Digital Transformation of Ukraine. (2025). Rekomendatsii shchodo vidpovidalnoho vprovadzhennia ta vykorystannia tekhnolohii shtuchnoho intelektu v zakladakh vyshchoi osvity [Recommendations for the responsible implementation and use of artificial intelligence technologies in higher education institutions]. https://mon.gov.ua/news/shtuchnyi-intelekt-u-zakladakh-vyshchoi-osvity-rekomendatsii-dlia-vykladachiv-studentiv-i-pratsivnykiv-zvo

19. Morze, N. V., Boiko, M. A., Strutynska, O. V., & Smyrnova-Trybulska, Ye. M. (2024). Yakoiu maie buty tsyfrova kompetentnist vchyteliv u haluzi vykorystannia shtuchnoho intelektu? [What should teachers' digital competence in the use of artificial intelligence be?]. Vidkryte osvitnie e-seredovyshche suchasnoho universytetu, (16), 76–91. https://doi.org/10.28925/2414-0325.2024.166

20. Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence (Artificial Intelligence Act), 2024 O.J. (L 1689). http://data.europa.eu/eli/reg/2024/1689/oj

21. Russell, S., & Norvig, P. (2020). Artificial intelligence: A modern approach (4th ed.). Pearson.

22. Searle, J. R. (1980). Minds, brains, and programs. Behavioral and Brain Sciences, 3(3), 417–424. https://doi.org/10.1017/S0140525X00005756

23. Shakotko, V. V. (2018). Metodychna systema formuvannia informolohichnykh kompetentnostei maibutnikh uchyteliv informatyky [Methodological system for developing informological competencies of future informatics teachers] [Candidate dissertation, National Pedagogical Dragomanov University].

24. Turing, A. M. (1950). Computing machinery and intelligence. Mind, 59(236), 433–460. https://doi.org/10.1093/mind/LIX.236.433

25. Vorotnykova, I., Dziabenko, O., & Morze, N. (2025). Vyklyky vprovadzhennia personalizovanoho navchannia z vykorystanniam shtuchnoho intelektu u vyshchii osviti [Challenges of implementing personalized learning using artificial intelligence in higher education]. Informatsiini tekhnolohii i zasoby navchannia, 105(1), 144–157. https://doi.org/10.33407/itlt.v105i1.5893

26. Wei, J., Wang, X., Schuurmans, D., Bosma, M., Ichter, B., Xia, F., Chi, E., Le, Q. V., & Zhou, D. (2022). Chain-of-thought prompting elicits reasoning in large language models. Advances in Neural Information Processing Systems, 35, 24824–24837.