Metaverse Basic and Applied Research. 2025; 4:164
doi: 10.56294/mr2025164

ORIGINAL

Enhancing the Educational Process through AI and Gamified Learning

Mejorar el proceso educativo mediante la IA y el aprendizaje gamificado

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Cite as: Zhumbei M, Khairulin O, Buniak N, Sapohov M, Parfilova S. Enhancing the Educational Process through AI and Gamified Learning. Metaverse Basic and Applied Research. 2025; 4:164. https://doi.org/10.56294/mr2025164

Submitted: 02-05-2024 **Revised:** 10-10-2024 **Accepted:** 12-03-2025 **Published:** 13-03-2025

Editor: PhD. Yailen Martínez Jiménez

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ABSTRACT

AI provides a wide range of tools for creating personalised learning paths and unlocking each student's potential. The study aims to investigate the effectiveness of integrating AI tools into the educational process to form personalised learning paths. In the study context, the methods of self-assessment, analysis of learning outcomes, and statistical calculation of pedagogical experiment data processing were used. Criteria for the effectiveness of integrating AI into the educational process to develop personalised learning paths have been formed. Based on the outlined criteria and levels of their implementation, the most effective ones are identified through self-assessment. The tools for implementing these AI-based learning tools are outlined. The higher education students for whom the AI-based learning tools were used were divided into clusters according to their professional training: humanities, social sciences, and engineering. The pedagogical experiment compared the learning outcomes of the control group that used randomly selected AI tools and the experimental group that used AI-based learning tools, distributed according to the clusters of professional training. Based on the statistical comparison of learning outcomes, it was determined that the experimental group shows better results. Therefore, the preliminary analysis of AI-based learning tools and their further application by the clusters of professional training is practical.

Keywords: Accounting; Artificial Intelligence; Blockchain; Cloud Technologies; Outsourcing; Financial Innovation; Subject; Game Modeling; Edutainment.

RESUMEN

El estudio pretende investigar la eficacia de integrar herramientas de IA en el proceso educativo para formar itinerarios de aprendizaje personalizados. En el contexto del estudio se utilizaron la autoevaluación, el análisis de los resultados del aprendizaje y el cálculo estadístico del procesamiento de datos de experimentos pedagógicos. Se han formado criterios de eficacia de la integración de la IA en el proceso educativo para desarrollar itinerarios de aprendizaje personalizados. Sobre la base de los criterios esbozados y los niveles de su aplicación, se identifican los más eficaces mediante autoevaluación. Se esbozan las herramientas para implantar estas herramientas de aprendizaje basadas en la IA. Los estudiantes de enseñanza superior para los que se utilizaron las herramientas de aprendizaje basadas en IA se dividieron en grupos según su formación profesional: humanidades, ciencias sociales e ingeniería. El experimento pedagógico comparó

los resultados de aprendizaje del grupo de control que utilizó herramientas de IA seleccionadas al azar y el grupo experimental que utilizó herramientas de aprendizaje basadas en IA, distribuidos según los clusters de formación profesional. Basándose en la comparación estadística de los resultados del aprendizaje, se determinó que los resultados del grupo de control superaban a los del grupo experimental. Por lo tanto, resulta práctico el análisis preliminar de las herramientas de aprendizaje basadas en IA y su posterior aplicación por parte de los grupos de formación profesional.

Palabras clave: Contabilidad; Inteligencia Artificial; Blockchain; Tecnologías en la Nube; Externalización; Innovación Financiera.

INTRODUCTION

The development of digital technologies has brought about rapid changes in modern education, and artificial intelligence (AI) has become a powerful impetus for the transformation of educational approaches. However, there are many controversies in modern pedagogical science regarding the use of AI in education, and this issue requires analysing AI tools and implementing strategies for their use in the educational process.

The development and implementation of new approaches in vocational education are driven by the development of technologies and the need to implement them in further professional activities. The personalised needs of higher education students cannot always be considered when using traditional teaching tools, which affects the effectiveness of learning. Therefore, in the context of global digitalisation, including in the context of professional training of higher education students, the issue of implementing AI tools is becoming increasingly relevant.

However, in the context of the outlined field of research, problematic issues need to be addressed, namely, improving the level of teacher training to work with AI tools, ethical issues of controlling the acquisition of knowledge and choosing the right AI tools to create personalised learning paths that fully reveal the potential of higher education students and improve the quality of education. The paper studies the prospects for introducing artificial intelligence tools into the educational process to create personalised learning paths.

The authors Hossain et al.,[1] Washizaki and Yoshioka[2] outline the prospects for introducing AI tools into the educational process to optimise it and increase the engagement of higher education students. Tanaka et al.[3] and Olson[4] consider the peculiarities of using artificial intelligence and machine learning in the formation of courses in academic disciplines. Guo and Xue,[5] Luo et al.[6] determined that AI tools can adapt learning content and teaching methods to the personalised needs of higher education students, providing an analysis of successes, difficulties and knowledge gaps.

Vhatkar et al.[7] note that AI has also led to the emergence of concepts such as education and game modeling. Researchers Wang and Yu,[8] Oliynyk et al.[9] find that the integration of AI systems and gaming technologies increases the motivation of higher education students. In their works, Abate et al.[10] and Babenko et al.[11] outline the prospects for using real-life modeling through the introduction of virtual simulations in the context of the educational process, which ensures the acquisition of practical competencies.

Fu[12] and Xia et al.[13] identify the need to preserve the student's subjectivity in the context of the educational process, and AI should be given the role of an assistant and a tool for developing critical thinking. Also, Neumann et al.[14] note that the use of AI tools is a way to transform education fundamentally, but Trishch et al.[15] emphasise the need to find methods for assessing the effectiveness of the implementation of these systems and the impact of this implementation in the long term. Ali et al.[16] outline the potential of introducing AI into the educational process but emphasise the need to comply with ethical standards and balance between digital tools and practice-oriented classroom learning.

In response to the problems of uniqueness and lack of personalised teaching in traditional education models, Yang[17] created a personalised networked autonomous learning platform based on digital empowerment technology. Murad et al.[18] outline technology for determining the fullest possible use of online learning opportunities through an individualised recommendation system based on the user's history of interaction with the system. Babu et al.[19] present a new approach to improving personalised learning experiences. This type of learning aims to tailor learning content and strategies to students' individual needs, improving engagement and learning outcomes to provide a more accurate understanding and recommend relevant materials.

Huang and Liang[20] note that Generative AI offers new opportunities for teaching and learning, where the role of the teacher will be changed and the way students learn will be transformed. Traditional online learning systems have long response times and low accuracy in predicting student behaviour, learning outcomes, or personalised needs. In order to make improvements in these aspects, Ma[21] created a personalised online artificial intelligence learning system based on STEAM. The new generation of information technology has

triggered a powerful wave of digitalisation in the world, contributing to the digital transformation of higher education. Faced with the challenges of these new changes, universities worldwide are actively exploring new education models and ways to implement AI. Xu[22] presents new forms of digital education, such as flexible education, sustainable competence-based education, AI+ education, service-oriented education, and meta-world education. Smith[23] presents a qualitative analysis of data collected from higher education ICT teachers and technology industry employers, outlining priorities in training qualified professionals and noting the leading place of AI in professional training.

Objective of the study: the work is devoted to the study of the prospects for implementing artificial intelligence tools in the educational process to create personalized learning trajectories.

METHOD

The investigation is experimental. In the course of studying the prospects for the development of personalised learning in the context of integrating artificial intelligence into the educational process, the methods of questionnaires, pedagogical experiments and statistical processing of learning outcomes of higher education students when using AI tools to form personalised learning paths are used.

The study was conducted at Vasyl Stefanyk Precarpathian National University, the National Defence University of Ukraine, and Western Ukrainian National University during the 2023–2024 academic year. The study was conducted in two stages: the first was the analysis of AI tools and the selection of the most effective ones based on self-assessment, and the second stage was the implementation of the selected AI tools in the educational process and evaluation of learning outcomes. The self-assessment questionnaire is based on a 12-point scale. A total of 36 lecturers were involved in selecting AI tools to create personalised learning paths.

The essence of the pedagogical experiment is to compare the effectiveness of the use of AI tools that were randomly distributed and the use of AI tools differentiated according to the clusters of professional training by field (G1 for humanities, G2 for social sciences, G3 for engineering). The study of the progress of learning outcomes in implementing AI tools was carried out based on an analysis of the learning achievements of 126 higher education students, 63 of whom were in the control group and 63 in the experimental group. The control group studied with the help of learning tools, for the integration of which AI-based tools were implemented, as outlined in Figure 1. The experimental group used AI-based learning tools to implement personalised learning trajectories, which were selected during the self-assessment stage as the most effective, as revealed in the analysis presented in figure 2. The participants were randomly assigned to the control and experimental groups. The annual average grade point average of higher education students in all disciplines according to the curriculum was taken as the learning outcomes. To confirm the hypothesis about the effectiveness of using the outlined range of artificial intelligence tools to create personalised learning paths, the Student's statistical test was applied. The pedagogical experiment compared the use of a range of AI tools to create personalised learning paths and pre-selected AI tools that meet the criteria and goals of training higher education students, which were divided into clusters according to professional needs.

The sample is random and the observations are independent of each other. Participation in the study was voluntary, and all respondents were informed about the purpose of the survey and had the opportunity to refuse participation at any stage. Confidentiality of personal data was ensured, and the results were presented in an anonymized form. Thus, the ethical principles of conducting social research were observed.

RESULTS

With the advent of AI systems, there is an increasing tendency to change traditional roles in the context of the educational process. The educational process involves a student, a teacher, the administration of a higher education institution, and an AI system that acts as a full-fledged subject of the educational process. The interaction of the subjects of the educational process is shown in Figure 1, where the AI system can be an intermediary between the participants of the educational process, the creator of the initial content and a tool for acquiring knowledge.

In the AI era, students are not just participants in the educational process but active creators of their learning path, which considers their abilities and preferences and provides recommendations on improving their knowledge acquisition. AI systems also reduce the routine work for teachers, allowing them to focus on mentoring. Thanks to the AI system, the administration of a higher education institution can make more accurate and informed decisions to improve the educational process based on predictive and analytical models. AI-based assistants provide other actors in the educational process with advice and tips on how to solve tasks, and interaction with them becomes a full-fledged part of the educational process.

A self-assessment was conducted based on a survey of teachers to evaluate the implementation of personalised learning strategies through the integration of AI. A total of 36 teachers participated in the study, who integrated artificial intelligence tools when developing personalised learning paths for higher education students. The questionnaire (Appendix 1) was developed based on four criteria, the indicators of which are

detailed in Table 1.

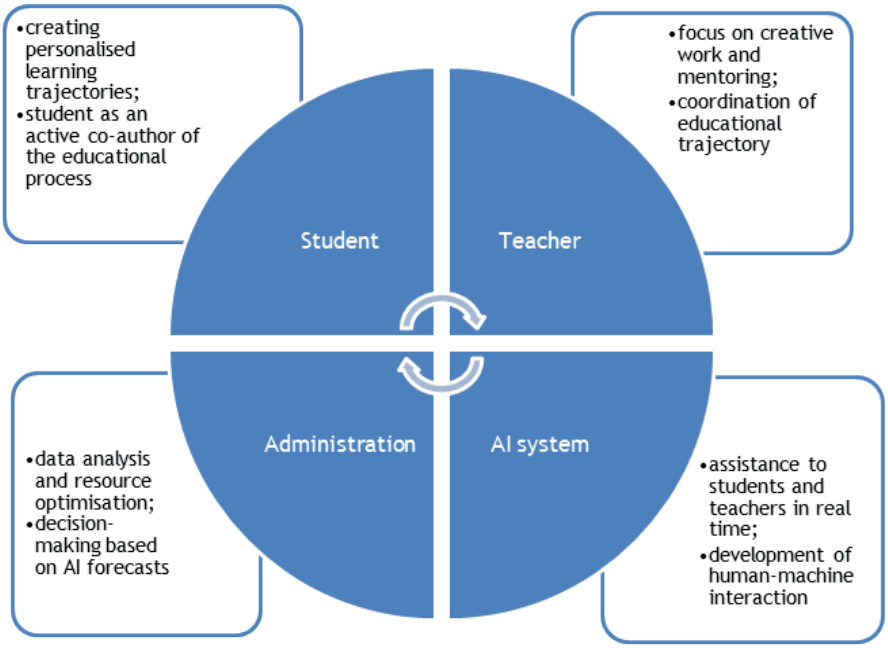

Figure 1. Interaction of subjects of the educational process in the age of AI
Source: compiled by the author

Table 1. Criteria for the effectiveness of integrating AI into the educational process to develop personalised learning paths

Criterion	Criterion indicators
Individualisation of learning (C1)	Improving learning outcomes
	System response speed for adjusting the educational trajectory
	Satisfaction level of higher education students
Engagement and interactivity (C2)	Frequency and activity of interaction of higher education students with learning materials
	Frequency of modification or updating of learning content
	System proposals for engaging higher education students in group learning activities
Accuracy and quality of recommendations provided by the AI system (C3)	Accuracy of AI system forecasting methods for implementing individual educational trajectories
	The degree of relevance of recommendations by the level and interests of the higher education student
	AI system proposals to improve the level of recommendations throughout the educational trajectory
The system's ability to adapt and scale (C4)	The ability of the system to work with a large number of users and the ability to process a large amount of data
	The ability of the system to adapt to different educational programmes and learning contexts
	Ability to integrate with learning management systems and other educational platforms

Based on the questionnaire presented in Appendix 1, we identified the levels of efficiency of integrating AI into the educational process to develop personalised learning paths. High-level indicators corresponded to scores of 9–12, medium – 5-8, and low – 1-4. The levels of effectiveness of integrating AI into the educational process to develop personalised learning paths allow us to classify the progress and effectiveness of using AI tools by the criteria outlined.

The entry-level is characterised by the limited functionality of the AI tool, which is effective for data analysis and basic recommendations. The system does not consider the personalised needs of higher education students and is based on template algorithms. The middle level is better at ensuring individualisation of educational

https://doi.org/10.56294/mr2025164

trajectories, but the moderator needs to improve and correct the integration of tools into educational platforms. The interactive characteristics of learning tools are also noted. The high level of AI integration into the educational process to develop personalised learning paths allows for the full integration of the AI system into the educational process and meets the individual needs of the higher education student. A wide range of educational technologies provides interactivity, gamification, and collaborative learning. It also provides easy adaptation to different amounts of educational content and groups of higher education students.

Figure 2 shows the results of the self-assessment of AI tools for creating personalised learning paths. In total, the following AI tools were identified: the formation of educational trajectories based solely on user preferences, a standardised template learning format, knowledge verification through testing, diverse learning platforms, adaptive educational systems, virtual assistants and chatbots, gamification and educational tools, data analysis and student success forecasting. They were evaluated according to the criteria presented in table 1.

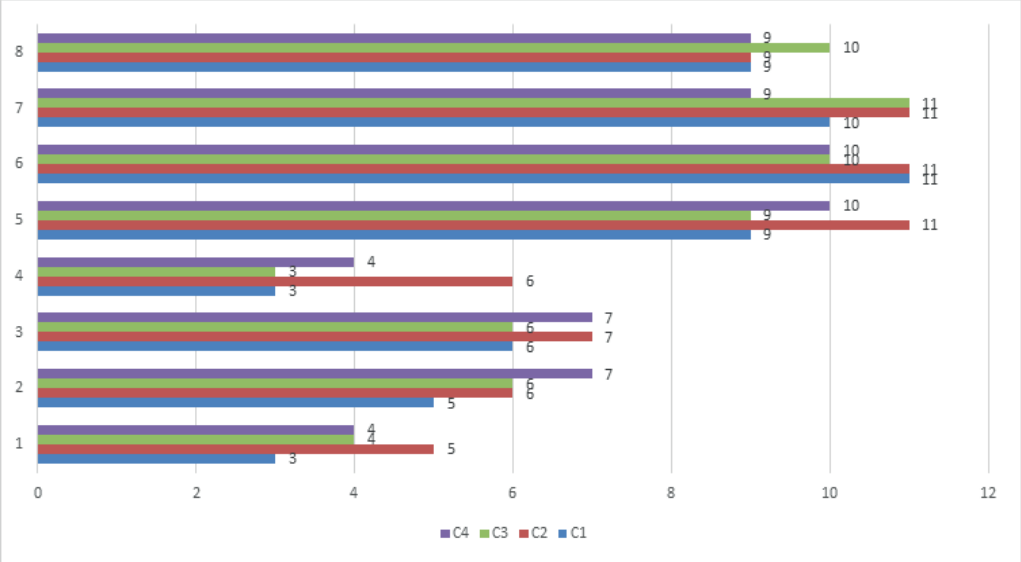

Figure 2. Results of self-assessment of AI tools for creating personalised learning paths

Keywords: 1 – formation of educational trajectories solely based on user preferences, 2 – standardised template learning format, 3 – knowledge verification through testing, 4 – disparate learning platforms, 5 – adaptive educational systems, 6 – virtual assistants and chatbots, 7 – gamification and educational tools, 8 – data analysis and prediction of student success; C1, C2, C3, C4 – self-assessment criteria (according to table 1)

According to the results of the self-assessment of AI tools for creating personalised learning paths, the level of such tools as forming educational paths solely based on user preferences, standardised template learning format, knowledge verification through testing, and disparate learning platforms was determined as medium or low. At the same time, adaptive learning systems, virtual assistants and chatbots, gamification and educational tools, and data analysis and prediction of student success were rated high, making these AI tools for creating personalised learning paths a subject for further research.

There are presented AI tools for creating personalised learning paths implemented in the context of a pedagogical experiment in the Table 2: adaptive educational systems, virtual assistants and chatbots, gamification and edutainment tools, analysing data and predicting student success. A promising direction in the development of educational technologies is the psychodidactic technology of educational activity edutainment, as an alternative method to traditional education, which appeared as a result of the rapid development of means of communication and mass media. Learning with its help means the special use of educational material in the education of citizens, and not the use of entertainment methods, for example, role-playing, mobile games. Educational materials created on the basis of edutainment involve the use of a wide range of information technologies, including AI. Edutainment tools can be divided according to the goals and content of education into development to improve the quality of control of the educational process or informal education, which is usually presented in discussion or narrative forms and the dissemination and study of experience in mastering new learning skills (skills education), including in modeling (virtual mobility) of one's own participation in certain problematic social situations on known models.

Edutainment is also divided by target group into motivational encouragement of users who have the same interest regardless of their age, level of knowledge, etc. and problem orientation to a certain category. At the same time, this innovation involves the integration of technical and didactic means with a game-filled education. The introduction of modern means of communication, such as video and audio materials, films, music, board and video games, multimedia and Internet AI-based resources into the traditional education system also requires the

https://doi.org/10.56294/mr2025164

integration of the edutainment method into the educational process.

The selected AI tools were evaluated to develop personalised learning paths in the context of training higher education students, divided according to the clusters of professional training into humanities, social sciences and engineering, divided into three groups: G1, G2, and G3. Table 2 summarises the results of the evaluation of AI tools that scored high according to the survey, which are proposed to be used for the training of higher education students in the above groups: G1 – for the humanities, G2 – for the social sciences, G3 – for engineering.

Table 2. AI tools for creating personalised learning paths implemented in the context of a pedagogical experiment.

AI tool	The essence of the product	AI tool for G1	AI tool for G2	AI tool for G3
Adaptive educational systems	Analysing the learning preferences of students, adjusting the complexity of tasks to the level of students	DreamBox Learning - action analysis for creating personalised learning paths Natural language processing algorithms	Smart Sparrow - creating adaptive courses based on students' characteristics and preferences	Knewton allows for the selection of materials based on complexity and level of knowledge Machine learning algorithms
Virtual assistants and chatbots	Real-time support for students, providing recommendations on the learning process	Duolingo - used for personalisation when learning languages	ChatGPT - provides training recommendations and educational materials	IBM Watson Assistant - provides personalised support and answers to questions
Gamification and edutainment tools	Use of game elements in teaching and adaptation to the needs of the student in the context of the game	Quizlet - creates tests and flashcards that adapt to the student's needs AR/VR solutions: Oculus	Kahoot - creating quizzes and game tasks AR/VR solutions: HoloLens, CoSpaces EDU	Classcraft - using gamification elements to create individual educational trajectories AR/VR solutions: CoSpaces EDU
Analysing data and predicting student success	Identify knowledge gaps and track personal progress	Gradescope - automatically checks assignments and tests and identifies areas for improvement Tableau analytical systems are integrated with educational platforms	Cerego uses machine learning algorithms to predict the complexity of materials Power BI analytical systems are integrated with educational platforms	Predictive Analytics (via R or Python) - creating personalised learning paths based on data from higher education students

Notes: G1 – AI-based tools for the humanitarian field, G2 – AI-based tools for the social field, G3 – AI-based tools for the engineering field

The final stage compared learning outcomes before and after implementing the identified AI tools to form personalised learning paths. For the statistical comparison of learning outcomes, the control and experimental groups were divided into three subgroups by professional training clusters – G1, G2, and G3 – according to the educational programmes they studied. Table 3 shows the division of participants in the pedagogical experiment.

Table 3. Distribution of participants in the pedagogical experiment

	G1	G2	G3	Total
CG	21	21	21	63
EG	21	21	21	63

Notes: CG – control group, EG – experimental group, G1, G2, G3 – subgroups of higher education students according to the educational programmes they study

Two hypotheses were accepted for the statistical calculation: H0-the difference between the two indicators is statistically insignificant, and H1-the difference between the two indicators is statistically significant. To confirm the effectiveness of the hypotheses put forward during the pedagogical experiment, the effectiveness of integrating artificial intelligence tools in the formation of personalised learning paths was statistically tested. For statistical verification, the Student's t-test was used to assess the differences in the values of the means of the two samples.

Critical values: Prior to introducing differentiation of artificial intelligence tools in the formation of individual learning trajectories, an input measurement of learning indicators of higher education students of the control and experimental groups was carried out. Table 4 shows the statistical indicators of higher education students of the control and experimental groups who studied using traditional teaching methods with the introduction of online learning tools.

https://doi.org/10.56294/mr2025164

Table 4. Input control of learning outcomes of higher education students before the pedagogical experiment

No	Samples		Deviation from the average		Deviation squares	
	CG	EG	CG	EG	CG	EG
G1	66	68	-4	-3	16	9
G2	73	74	3	3	9	9
G3	71	71	1	0	1	0
Amounts:	210	213	0	0	26	18
Average:	70	71				

Notes: CG – control group, EG – experimental group, G1, G2, G3 – subgroups of higher education students according to the educational programmes they study

As a result of the t-test calculation, the empirical value of temp.=0.4 is in the zone of insignificance. Therefore, we accept the hypothesis H0 – the difference between the two indicators is statistically insignificant.
Table 5 shows the statistical indicators of higher education students of the control group who studied with AI-based learning tools that were undifferentiated according to the learning clusters and the experimental group who studied with learning tools selected according to the criteria and professional clusters: humanities, social sciences, and engineering.

Table 5. Baseline control of learning outcomes of higher education students after the pedagogical experiment

No	Samples		Deviation from the average		Deviation squares	
	CG	EG	CG	CG	EG	CG
G1	67	81	-2,33	-5,33	5,4289	28,4089
G2	70	89	0,67	2,67	0,4489	7,1289
G3	71	89	1,67	2,67	2,7889	7,1289
Amounts:	208	259	0,01	0,01	8,6667	42,6667
Average:	69,33	86,33				

Notes: CG – control group, EG – experimental group, G1, G2, G3 – subgroups of higher education students according to the educational programmes they study.

Calculating the t-test revealed an empirical value of t_{emp}.=5,8, which is in the zone of significance. Thus, we accept the hypothesis $H_{(1)}$ – the difference between the two indicators is statistically significant, and, therefore, the identified AI tools are effective in forming personalised learning paths.

DISCUSSION

The key to implementing a personalised user learning trajectory is correctly and appropriately placing learning resources and educational content. Zhu and Lin[24] outline an artificial intelligence recommendation algorithm integrated to create a personalised recommendation system for learning resources. The first step of this algorithm is to classify user interest tags in the recommendation system by combining the classification algorithm with labels from the user's digital portrait composition technology. An accurate, personalised learning path planning system has been developed based on a student's digital portrait. Thus, the advantages of personalising learning and using AI tools in implementing personalised learning paths have been identified. Nevertheless, the preliminary selection of AI tools that meet the criteria of the speciality's educational programme and control of their implementation in the context of the educational process are important aspects outlined in the current study.

The AI can support different educational purposes such development of content, administrative process of higher education institutions, play role of intelligent assistant. In their study, Batsurovska al.[25] outline application of artificial intelligence in the higher education system. The point of view of authors correlates with the current research and indicates that AI is a powerful tool of the development of personalized learning path. The study by Chen et al.[26] examines the views of Chinese university professors on integrating artificial intelligence into generative content. The study aims to understand the concerns and prepare for introducing AI generative tools in art and design curricula. The research highlights the potential benefits of AI in education and concerns about its impact on traditional pedagogy. However, there is an urgent need to address equity issues related to resource mismatch, academic integrity, and cultural resistance within the educational community.

In the context of the current study, the authors emphasise that when introducing AI tools into the learning environment, it is necessary to provide recommendations that outline the standardised use of AI tools and adaptation in professional structures to effectively harness the potential of artificial intelligence.

Engineering education today emphasises the need to combine traditional theoretical learning with a practice-oriented model. Researchers Vishnumolakala et al.[27] have developed the AI-based Research Companion (ARC) tool. The ARC uses advanced Generative AI technology, including GPT-4, to systematically organise, improve, and offer personalised guidance for student research projects. The platform aims to inspire students to research by making the process accessible and engaging, increasing participation in research activities. By combining GPT-4's advanced features with a user-centric design, ARC is an innovative platform highlighting Generative AI's key role in improving and expanding student research initiatives. The creation of a single platform for using the outlined range of AI tools to implement personalised learning trajectories by the chosen educational programmes is the prospect of further research by the authors.

The global shortage of qualified research and teaching staff is a serious challenge. The development of artificial intelligence opens up opportunities to address these challenges. Simaremare et al.[28] studied the use of GenAI among students in higher education institutions. The top five most used GenAI tools include GitHub Copilot, OpenAI ChatGPT, Codex, Grammarly, and ChatPDF. The study found that GenAI is already a part of the daily learning process and one of the many decisive factors in education systems, so there is a need to adapt and implement such systems in the learning environment. The current study's authors concluded that learning outcomes are improved when artificial intelligence tools are used to implement personalised learning paths. However, successful implementation of this technology is impossible without the participation of a teacher who also assumes the powers of a mentor, administrator, and mentor. Therefore, in the current study, the authors focus on the role of the teacher when applying AI systems to create personalised learning paths. For this reason, the selection of AI tools was based on the survey data obtained during a survey of academic staff, as the role of the teacher as a mentor who guides and motivates students remains irreplaceable.

CONCLUSIONS

The abilities, individual needs and interests of students of higher educational institutions are taken into account when forming personalized learning trajectories, and artificial intelligence tools are powerful for their implementation. The educational process with the help of game models and adaptive learning systems becomes more interactive, flexible and effective. Adaptation of educational materials to the needs of students of higher educational institutions, creation of virtual simulations for acquiring professional and practical competencies, as well as formation of individual educational trajectories are some of the main advantages of using artificial intelligence tools in educational activities.

Artificial intelligence tools for implementing the personalized learning process for professional clusters of students of higher educational institutions are outlined. It has been determined that the targeted selection of AI tools for students of higher education institutions divided into professional clusters provides better learning outcomes and generally has a positive impact on the educational process, increasing the level of motivation and engagement. The use of AI tools is aimed at improving the educational process and increasing the level of accessibility and individualization of learning, however, in this context, the role of the teacher as a mentor and moderator of the educational process comes to the fore.

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FUNDING

This research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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https://doi.org/10.56294/mr2025164