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Adaptation of pedagogical approaches to the implementation of intelligent systems in the educational process

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ABSTRACT

Interactive systems play an essential role in the modern educational system, but the issue of their optimization remains under-researched. Research purpose. The article aims to analyze the attitudes of teachers and students to the introduction of intelligent systems in the educational process, as well as to identify the main approaches to adapting pedagogical methods and key barriers. Research method. A purposive sample was used to include participants. Two groups were selected: students and teachers (60 participants in total). The main instrument in the study is a cross-sectional survey. Survey period: October – November 2024. Results. The findings show that intelligent learning technologies are known to all participants in the educational process: 32% actively use them, 52% are partially familiar with them, and only 14% determined that they rarely use them. Their effectiveness is undisputed, and their prospects are associated with increasing teaching efficiency. Among the problems in use are the lack of digital literacy, unresolved ethical issues, digital threats, and lack of necessary infrastructure. Recommendations are offered: increasing the motivational component, conducting special courses and training for teachers and students, improving technical support, and overcoming the shortcomings of the legislative framework. Conclusions. An essential potential of intelligent systems is their capabilities in gamification, blended learning, project-based learning, and the use of interactive lectures and seminars. The conclusions indicate that further adaptation of existing pedagogical approaches will require interactivity and adaptability.

Keywords: Personalized education. Interactive technologies. Educational innovations. Digital pedagogy. Adaptive methods

1. Introduction

Based on modern approaches, the educational process has undergone significant changes under the influence of technological progress, affecting intelligent systems' development and implementation. Modern scientific literature proves that using artificial intelligence (AI), adaptive learning technologies, big data analytics, and automated learning platforms allows for the effective organization of the educational environment [1, 2]. In addition, the authors have shown that these technologies allow for introducing a person-centered approach to the learning process and make it adaptive and interesting for each student [1, 3, 4]. However, they have also changed the role of the teacher, who has evolved from a knowledge carrier to a facilitator who mainly manages learning activities, analyses students' progress, and provides them with professional individual support.

In addition, scientific studies have shown that the process of adapting traditional pedagogical approaches to the use of intelligent systems is a complex process based on the modernization of standard methods, the introduction of new forms of knowledge assessment, and the development of digital competence of both teachers and students [2, 3, 5]. Therefore, the problem of adapting pedagogical approaches to the implementation of intelligent systems in the educational process is relevant and important for the development of scientific pedagogical discourse.

Without detracting from the significant potential of intelligent systems in education, the process of their integration remains ambiguous. On the one hand, they allow for the automation of certain aspects of teaching and provide students with individual learning trajectories, contributing to a person-centered approach. However, there is an essential problem with the effective adaptation of pedagogical methods to maintain quality educational interaction and prevent excessive technologization of the process. For this reason, the main research problem is to determine the optimal pedagogical strategies that will optimize the integration of intelligent systems into the learning process without losing the fundamental principles of education.

Therefore, this paper will focus on a detailed analysis of the main approaches that contribute to the effective implementation of intelligent systems in the educational process. The focus will be on methodological changes in teaching and the identification of technological opportunities for adapting existing educational programs. It is imperative to determine the attitude of teachers and students to the introduction of intelligent systems. Analyzing their opinions will allow us to formulate recommendations for improving the process of using AI, automated systems, adaptive learning technologies, and big data analytics. In addition, it is important to explore potential challenges associated with introducing intelligent systems in the educational process, including the risks of losing traditional approaches, privacy issues, and the need for additional support for teachers and students.

The current scientific discourse presents various aspects of using automated systems in education. Most modern works are devoted to the theoretical foundations of AI integration in education. For example, a few studies have identified the critical role of artificial intelligence in personalizing learning and emphasized the importance of analyzing educational data to optimize the learning process [2, 4, 6]. T. Cavanagh et al. proposed their solutions to adapting the learning process to introducing innovative systems [1]. Other works focus on analyzing adaptive learning systems that use machine learning algorithms to predict the basic needs of students [5]. At the same time, the study by E. Unamba et al. pointed out the importance of introducing additional courses for teachers and paying attention to their training, as technology requires an appropriate level of qualification [6]. In addition, modern works focus on the search for effective pedagogical strategies for integrating intelligent technologies into the educational process [1, 7, 8]. The authors describe the learning models under consideration and their impact on developing effective learning environments [9]. At the same time, C. Lin et al. conducted a systematic review of trends in introducing AI in education and described the main capabilities of these technologies [10]. The authors also stressed the need to develop new didactic models that use algorithmic solutions [10]. Another notable topic for analysis is the identification of the main advantages and challenges of using intelligent systems in education. Among the main advantages, scholars point to accessibility, the possibility of personalizing learning, and the automation of routine tasks (in particular, introducing control and tracking student progress) [4, 11, 12]. However, on the other hand, A. Alam raised critical ethical issues about whether robotic technology can replace teachers and described the significant impact of technological progress on the development of education and science [13]. In addition, the authors draw attention to other challenges. Since AI technologies analyze large amounts of personal data, this may lead to risks of violating students' privacy [14, 15, 16]. Another critical challenge is the need for additional training of teachers and students in using these technologies. Thus, students should be technically prepared to use intelligent systems in their practice, and teachers should have high digital literacy [14, 17]. There are also threats of losing critical thinking, as students may overly rely on algorithms' recommendations [18]. This, in turn, reduces their autonomy in learning. However, despite the considerable amount of research in this area, the issues of implementing optimal methods for combining

traditional pedagogical approaches with the capabilities of automated systems remain incompletely explored. Several studies point to the need to develop new methods for evaluating intelligent systems in education [19, 20], which opens areas for further research. It is also essential to determine the attitude of all participants in the educational process to introducing innovative automated systems and to determine their readiness for their widespread use. This study will fill this gap.

Therefore, the purpose of this paper is to determine the attitudes of teachers and students towards the introduction of intelligent systems in the educational process, as well as to identify the main approaches to adapting pedagogical methods and key barriers.

The main research questions are as follows:

1. What is the level of respondents' awareness of intelligent systems?
2. What is the level of readiness of teachers and students to use such systems?
3. What are the difficulties in integrating intelligent systems into teaching?
4. What recommendations can be made to adapt existing pedagogical approaches?

2. Research method

2.1. Research design

This study is a cross-sectional survey study. This methodological approach was chosen because of its ability to conduct a cross-sectional survey of different groups of participants in the educational process. The study involved two groups of participants, teachers, and students, which made it possible to characterize the attitudes of different groups toward the use of automated systems. Location: educational institutions of Ukraine. Survey period: October – November 2024.

2.2. Sample and participants

Two groups of participants were involved in the study: teachers and students, who had different experiences in using modern technologies. Information about the involvement of teachers and students was disseminated through personal contacts and corporate e-mails of educational institutions. In the information message, potential participants could find information about the objectives of the study, methods of conduct, and potential results. Therefore, the involvement of participants was based on purposive sampling, which was based on clear inclusion criteria that were different for both teachers and students. Table 1 shows detailed inclusion criteria for both groups.

Table 1. Participant inclusion criteria

Group	Criteria
Teachers	1. Involvement of teachers and scientific and pedagogical workers with work experience of 1 year or more. 2. The study includes persons working in higher or secondary education institutions. 3. The study participants understand what artificial intelligence is, the automation of the educational process. 4. Teachers who use modern technologies in the educational process. Persons who show willingness to adapt educational methods using intelligent systems. 5. Providing informed consent to data processing.
Students	1. Studying in pedagogical, technical, or other specialities related to education and technology. 2. Study participants understand what artificial intelligence and automation of the educational process are. 3. Interest in the digitalisation of the educational process. 4. Providing informed consent to data processing.

The specified criteria helped to ensure the sample was representative and the data was correct. Therefore, 60 participants were included in the study using these criteria: 20 teachers and 40 students.

Table 2. Data of the survey participants

Category	Participants N	Participants %	Average age, years	Sex M/F	Educational level	Type of educational institution	Use of technology
Teachers	20	33,33%	41 ± 5	8/12	PhD (50%) Doctor of Science (20%) Master (30%)	Higher education institution Research Institute College	+ Knowledge of all technologies and their use
Students	40	66,67%	21 ± 3	15/25	Bachelor (60%) Master (40%)	Higher education institution	+ Knowledge of all technologies

2.3. Instruments and procedure

The primary tool in the study is a cross-sectional survey. The survey was conducted simultaneously so that both teachers and students could maximally record their attitudes toward the use of automated systems. The survey was conducted from October to November 2024. Participants completed the survey online using Google Forms. The developed questionnaire consisted of closed and open questions related to demographic data, opportunities for implementing modern automated technologies, barriers to their use, and potential ways to improve the system for adapting the educational process. Table 3 shows the main survey questions.

Table 3. Survey template

General data	1. Please indicate your role in the educational process. 2. Please indicate your age and work experience (if any) 3. Please indicate your educational institution 4. Please indicate your specialization 5. Please indicate your educational level
Level of awareness	6. Do you use modern technologies in the educational process? 7. Are you familiar with the concept of "intelligent systems" in the educational process? Yes, I understand the entire content Partially No, I hear it for the first time 8. What intelligent systems are you familiar with or do you use? Adaptive learning systems (in particular, Coursera, EdX, and Duolingo) Virtual assistants or chatbots Automated assessment systems Other
Advantages	9. State the advantages of using intelligent automated systems
Disadvantages	10. What aspects influence the successful implementation of intelligent systems? 11. What are the main difficulties in the implementation of intelligent systems?
Recommendations	12. What basic teaching methods should be adapted using intelligent systems?

2.4. Data analysis

After data collection, the responses were categorized for quantitative analysis. Percentages were calculated for all responses received. Microsoft Excel software was used to analyze the data. All responses were categorized according to the following areas:

1. Level of awareness of participants
2. Identified opportunities
3. Challenges
4. Recommendations.

All open-ended responses were transferred to Microsoft Word and categorized according to the main areas: opportunities, challenges, and recommendations. Correlation statistics were used to analyze the relationships between parameters. Graphs were constructed to visualize the data, expressing the primary data obtained. The comparative analysis method was also used to correlate the responses with the results of other researchers.

3. Results and discussion

Modern technologies are essential for the transformation of the educational process, in which digital intelligent systems play an essential role [21]. At the same time, there is a list of issues that need to be considered when implementing them. Respondents were asked to determine their awareness of using intelligent systems (Figure 1).

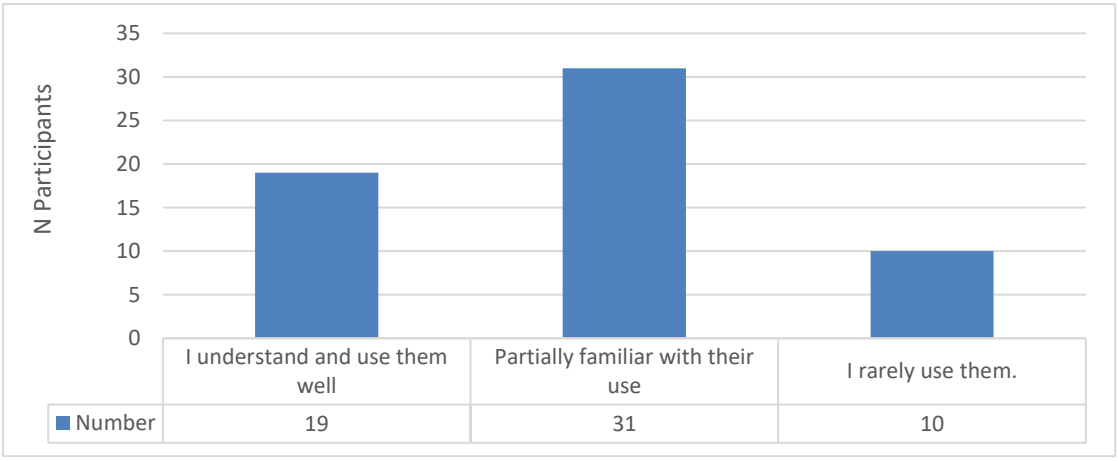

Figure 1. Level of awareness regarding the use of intelligent systems

Therefore, according to the survey, most respondents are familiar with the use of intelligent systems in education. In particular, 19 respondents (32%) actively use them, 31 respondents (52%) are partially familiar with them, and only 10 respondents (14%) determined that they rarely use them. Accordingly, it was further proposed that intelligent systems be specified (Figure 2).

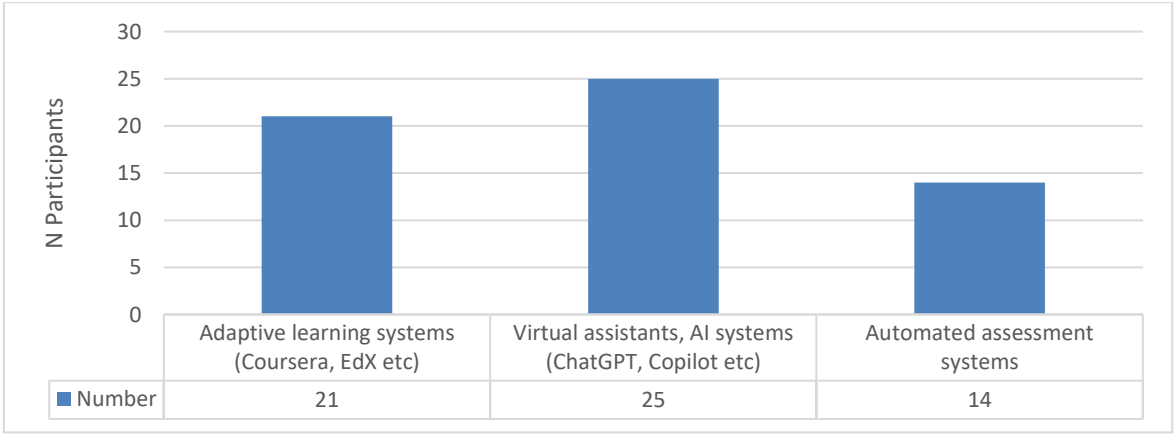

Figure 2. The most popular intelligent systems in education

Most respondents indicated that they most often use virtual assistants, including modern artificial intelligence systems (25 respondents, or 42%). However, specialized educational systems are also among the leaders in their use, with 21 respondents noting their importance (35%). In contrast, automatic assessment systems are less popular and are in widespread use, although 14 respondents (23%) identified their relevance. The results show that respondents are actively using intelligent systems in the educational process. In addition, all the most common opportunities for intelligent digital learning are used to varying degrees (obviously, their use may depend on the characteristics of the educational process) [22]. Accordingly, it was proposed that the potential benefits of using intelligent systems be identified (Figure 3).

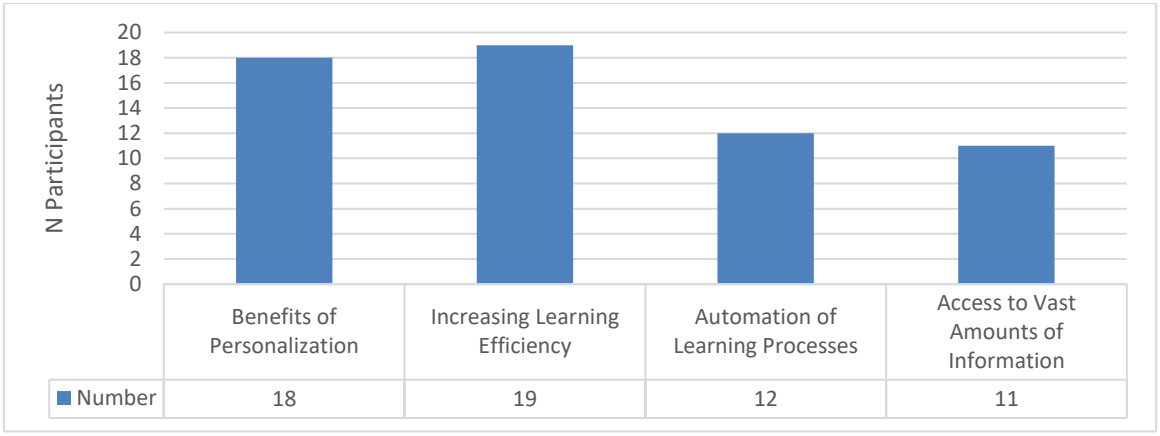

Figure 3. Potential benefits of intelligent systems

Thus, respondents identified some prospects for further application of intelligent systems in education. First, it is about the leadership of personalization of learning (18 respondents, or 30%) and improving teaching effectiveness (19 respondents, or 32%). On the other hand, the respondents also identified the advantages of automating learning (12 respondents, or 20%) and access to large amounts of information with the ability to process it (11 respondents, or 18%). These results point to critical areas for further adaptation of digital intelligent systems for educational purposes. It is important to note that the advantage of improving teaching efficiency is still small. Digital technologies have made it possible to significantly diversify the conduct of classes [23, 24]. As technology is constantly evolving, it is also possible to further incorporate changes into the pedagogical process [25, 26]. However, this will also require considering the existing difficulties that will arise during the further digital intensification of education (Figure 4).

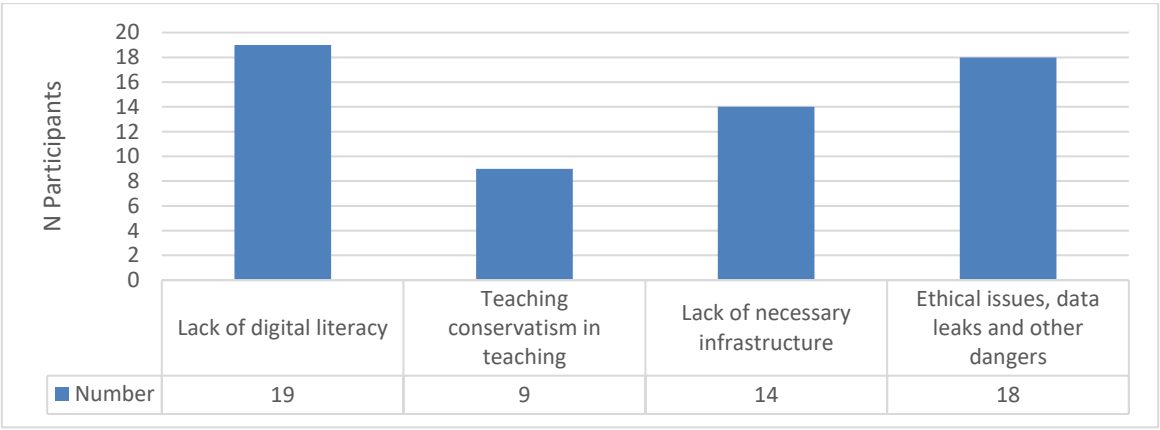

Figure 4. Potential challenges of using intelligent systems

The survey has shown that the further use of innovative educational systems is not without threats. Among these threats, the lack of digital literacy is recognized as the highest ranking (19 respondents, or 32%). This problem is also recognized by other researchers, who generally point out that in the modern world (with the impact of digital technologies on it), it is worth intensifying the teaching of digital competence and starting it at an early age. Respondents also noted the importance of ethical issues, digital threats (opportunities for fraud), etc. (18 respondents, or 30%). Although this problem is partly related to digital competence, specific Ukrainian realities

are also important. Russian aggression and the hybrid challenge it has created create additional cybersecurity for all users in Ukraine, including students and teachers [27]. The identified problem of lack of necessary infrastructure (14 respondents, or 23%) points to the financial and managerial problems in the Ukrainian education system, which the Russian military invasion has significantly exacerbated. At the same time, there is also a problem of resistance to change on the part of teachers (9 respondents or 19%), which may be localized. The further evolution of digital intelligent systems requires the adoption of specific decisions that will facilitate the evolution of this process (Figure 5).

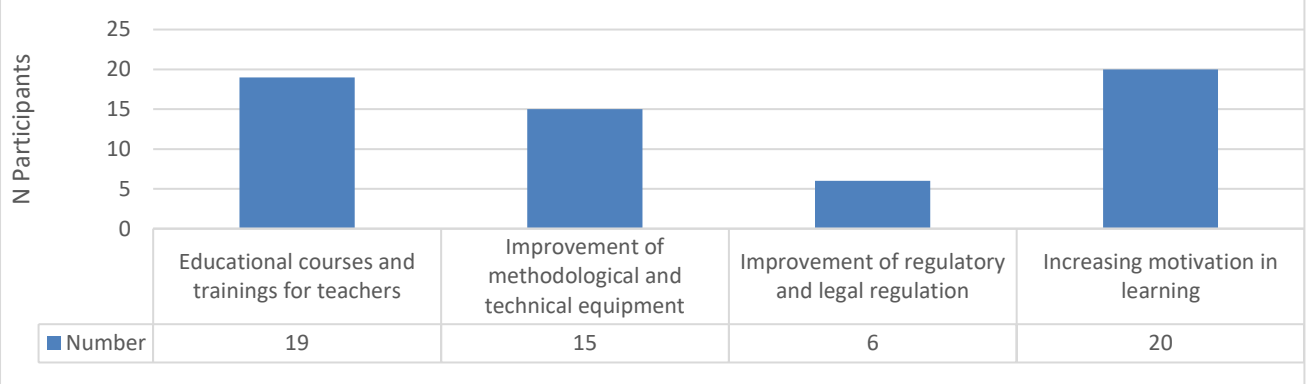

Figure 5. Further successful integration of intelligent systems

Respondents identified the motivational component as one of the most essential elements of further integrating intelligent systems into the educational process (20 respondents, or 34%). At the same time, among the favorites are also holding special courses and training for teachers and students - 19 respondents (32%). A significant percentage of respondents also identified a good opportunity to improve technical support, which would make it possible to update the digital capabilities of educational institutions (15 respondents, or 24%). The need to overcome existing administrative barriers, which are also created because of an ineffective legislative framework, was identified by only 6 respondents (10%). Such results allow us to indicate that, despite all the difficulties, motivation remains one of the biggest drivers of the application of innovations in education. Respondents also provided important recommendations regarding teaching methods that should be used in the future (Figure 6).

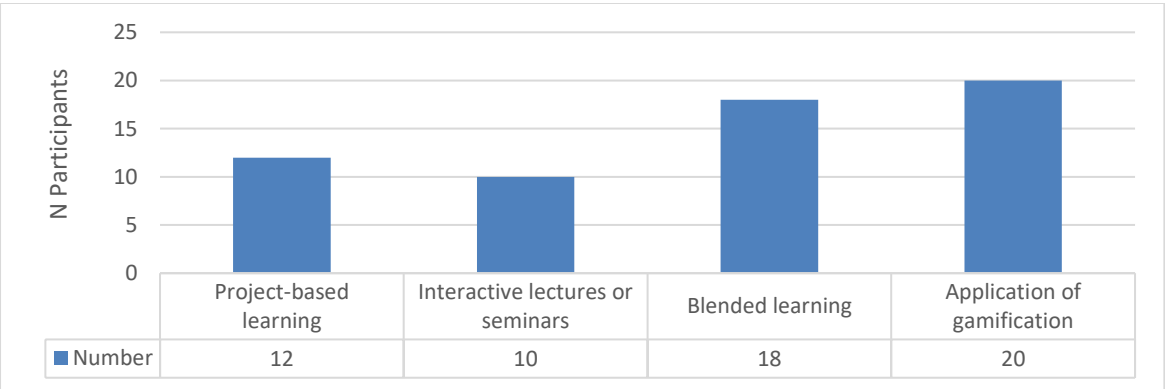

Figure 6. Teaching methods that should be adapted to use intelligent systems

Thus, respondents believe that for the further development of intelligent digital systems in education, their potential can be used primarily in gamification (20 respondents, or 34%). Blended learning is also relevant, as it will allow the use of the advantages of distance learning with its digital development capabilities and elements of the traditional educational process (18 respondents, or 30%). The respondents identified the importance of intelligent systems in project-based learning (12 respondents, or 20%) and using interactive lectures and seminars (10 respondents, or 16%) at approximately the same level.

The proposed results can be compared with the research of other scientists who used empirical methods to measure the use of intelligent systems in education. This allowed us to confirm certain conclusions. The data obtained are shown in Table 4.

Table 4. Comparison of some obtained results with data from other scientists

Question	Results obtained	Data from other researchers
Level of awareness regarding the use of intelligent systems	Partially familiar with their use – 31 (51%)	Partially familiar with their use – 53% [4; 8]
Potential benefits of intelligent systems	Increasing Learning Efficiency – 19 (30%)	Optimising Learning Efficiency – 31–34% [8; 11; 16]
Further successful integration of intelligent systems	Increasing motivation in learning 20 (33%)	Boosting learning motivation 29–33% [4; 16]

Therefore, given the results, we can make specific recommendations for further adaptation of pedagogical approaches to the implementation of intelligent systems in the educational process. In particular, the analysis of the respondents' answers revealed that there is a specific combination of traditional and digital approaches to teaching, which provides flexibility in the use of pedagogical methods and the ability to create high-quality trajectories for personalizing learning. Interactivity and adaptability are also important tools, meaning that using intelligent systems makes it possible to create dynamic learning paths that are relevant to the modern educational process. Using such opportunities requires constant teacher learning, as digital tools are also being improved. For this reason, attention to teacher training (certain aspects of organizing training in the field of more effective use of artificial intelligence tools) should be transformed into high-quality lifelong education when acquiring new knowledge and skills is not a formal requirement but a real need. The further development of digital intelligent systems requires updating ethical aspects emphasizing the importance of adhering to the principles of academic integrity and transparency of the use of artificial intelligence algorithms or special programs for translation or text processing. The last step is establishing feedback and mandatory monitoring for students and faculty. The ongoing analysis allows us to identify problem areas in modern digital systems, overcome challenges, and eliminate the adverse effects of digitalization.

The modern development of digital technologies has had a specific impact on the functioning of educational systems worldwide. Despite the destructive Russian aggression, Ukrainian education has also been developing in line with global practices, integrating intelligent technologies into education. Therefore, the purpose of this article was to determine the attitude of teachers and students to the introduction of intelligent systems in the educational process, as well as to identify the main approaches to adapting pedagogical methods and key barriers. This task involved addressing several issues. In particular, the survey was designed to determine the level of respondents' awareness of intelligent systems, the level of teachers' and students' readiness to use such systems, to characterize the difficulties in integrating intelligent systems into teaching, and to offer recommendations for adapting existing pedagogical approaches.

The results show that most respondents are familiar with using intelligent systems. At the same time, 19 respondents (32%) actively use them, 31 respondents (52%) are partially familiar with them, and only 10 respondents (14%) rarely use them. In addition, virtual assistants, including modern artificial intelligence systems, were most often used (25 respondents, or 42%). Specialized educational systems were also used (21 respondents, or 35%), as well as automatic assessment systems (14 respondents, or 23%). The results confirm the findings of other researchers who have demonstrated that in modern education, most teachers and students of different levels use digital intelligent systems [6, 28, 29]. The findings also confirm the relevance of other research theories, including those about the tangible facilitation of the educational process using the benefits of intelligent systems [17, 30]. This indicates that such systems will require further consideration and practical use, which would allow them to be improved and enhanced.

The results demonstrated that teachers and students are ready to use intelligent systems in the educational process in the future. Some prospects, as identified in the survey, are related to improving teaching effectiveness (19 respondents, or 32%). The formation of convenient learning personalization trajectories (18 respondents, or 30%), further automation of learning (12 respondents, or 20%), and access to large amounts of information with

the ability to process them (11 respondents, or 18%). These findings generally confirm the results of other researchers who emphasize the increased teaching effectiveness due to using intelligent systems [22, 32]. Among the reasons for this phenomenon, they rightly point to the vast opportunities for diversifying classes, which, as we can assume, also fits the Ukrainian context [33]. However, some scholars argue that the impact of digitalization on education is overestimated, primarily due to the crisis conditions of the COVID-19 pandemic and related quarantine restrictions, and that global pedagogical practice will return to the wider use of the traditional model of education, which has proven effective for a long time [25, 34]. Although such studies are rather hypothetical, a partial revival of traditional teaching models is likely. However, the conclusions of scholars who believe that the deepening use of digital technologies is inevitable are more reasonable if only because of their rapid development and the learning opportunities they offer [35].

Some difficulties have also been identified that create problems on the way to further integration of innovative, intelligent systems into educational environments. Among the threats identified were the lack of digital literacy (19 respondents, or 32%), the importance of ethical issues, digital threats (opportunities for fraud), etc. (18 respondents, or 30%), the lack of necessary infrastructure (14 respondents, or 23%), and resistance to change from conservative teachers (9 respondents, or 19%). These results are generally confirmed by the findings of other researchers [8, 36]. However, the sequence (and therefore the rating) of the existing challenges may differ. For example, some studies identify the problem of ethics in the use of intelligent systems as the main one since the use of digital tools can lead to a significant improvement in learning outcomes, but at the expense of the assistance provided by artificial intelligence (editing texts, detecting errors in calculations, etc.) [24, 28, 37]. Other scholars emphasize the problem of conservatism of teachers and the administration of educational institutions as a reason for slowing down the digitalization of education [10], [38], [39]. The respondents' personal experience has an impact, which may differ from country to country. Although Ukrainian realities have their vision of the problems of using intelligent systems in education, the primary set of these problems is stable [40].

The results offer recommendations for adapting existing pedagogical approaches. In particular, the respondents identified the motivational component as one of the most important elements of further integrating intelligent systems into the educational process (20 respondents, or 34%). Also important are special courses and training for teachers and students (19 respondents, or 32%), improvement of technical support (15 respondents, or 24%), and overcoming the shortcomings of the legislative framework (6 respondents, 10%). At the same time, for the further development of intelligent digital systems in education, their potential can be used primarily in gamification (20 respondents, or 34%), blended learning (18 respondents, or 30%), project-based learning (12 respondents, or 20%), and the use of interactive lectures and seminars (10 respondents, or 16%). The results obtained are generally correlated with the calculations of other researchers [28, 41]. Accordingly, recommendations for further adaptation of existing pedagogical approaches for the broader use of intelligent systems will require considering interactivity and adaptability tools, focusing on teacher training, updating ethical aspects, establishing feedback, and conducting mandatory monitoring for students and teaching staff.

The methodology used in the study has certain limitations that need to be considered in the subsequent work with the proposed results. The survey method contains certain reservations about the subjectivity of the answers received. It may have been difficult for respondents to determine their level of proficiency in intelligent systems (how high or low it is and how often they use them) and to consider the difficulties of their use (for example, not all educational institutions have the proper infrastructure, etc.). At the same time, the answers received generally correlate with the results of other researchers. Therefore, it can be argued that subjectivity in the survey did not negatively affect the study results.

4. Conclusions

Therefore, integrating intelligent technologies into education is inherent in modern Ukrainian education. All participants in the educational process are familiar with their use. Virtual assistants, including artificial intelligence, specialized education, and automatic assessment systems, are most used. Their effectiveness is

undisputed, so teachers and students are ready to continue using intelligent systems in the educational process. Some prospects are related to improving teaching effectiveness, creating convenient learning personalization trajectories, further automation of learning, and accessing and processing large amounts of information.

Some difficulties have also been identified that create problems on the way to further integration of innovative, intelligent systems into educational environments. Among the threats identified are the lack of digital literacy, unresolved ethical issues, digital threats (opportunities for fraud), lack of necessary infrastructure, and resistance to change by conservative teachers. Although Ukrainian realities have their vision of the problems of using intelligent systems in education, the primary set of these problems is stable.

The recommendations include increasing the motivational component, conducting special courses and training for teachers and students, improving technical support, and overcoming the shortcomings of the legislative framework. At the same time, their potential can be used primarily in gamification, blended learning, project-based learning, and interactive lectures and seminars to develop intelligent digital systems in education further. Therefore, further adaptation of existing pedagogical approaches for the broader use of intelligent systems will require considering interactivity and adaptability tools, focusing on teacher training, updating ethical aspects, establishing feedback, and conducting mandatory monitoring for students and teaching staff.

While this study provides valuable insights into the integration of intelligent systems in education, it is not without limitations. Firstly, the survey method may include subjectivity as respondents' self-assessment of their proficiency and frequency of using intelligent systems could vary. Additionally, the infrastructure and resources available in different educational institutions were not uniformly accounted for, which may influence the generalizability of the findings. To strengthen the impact of future research, it is essential to conduct longitudinal studies that monitor the long-term effects of intelligent systems on education.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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Author contribution

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References

[1] T. Cavanagh, B. Chen, R. A. M. Lahcen, and J. Paradiso, “Constructing a Design Framework and Pedagogical Approach for Adaptive Learning in Higher Education: A Practitioner's Perspective”, *Int. Rev. Res. Open Distrib. Learn.*, vol. 21, no. 1, pp. 172–196, Jan. 2020. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.19173/irrodl.v21i1.4557

[2] T. M. Shamsutdinova, “Formation of Individual Educational Trajectory in Adaptive Learning Management Systems”, *Open Educ.*, vol. 25, no. 6, pp. 36–44, Nov. 2021. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.21686/1818-4243-2021-6-36-44

[3] N. Morze, L. Varchenko-Trotsenko, T. Terletska, and E. Smyrnova-Trybulska, “Implementation of adaptive learning at higher education institutions by means of Moodle LMS”, *J. Phys.: Conf. Ser.*, vol. 1840, no. 1,

p. 012062, Mar. 2021. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1088/1742-6596/1840/1/012062

[4] T. Kabudi, I. Pappas, and D. H. Olsen, "AI-enabled adaptive learning systems: A systematic mapping of the literature", *Comput. Educ.: Artif. Intell.*, vol. 2, p. 100017, 2021. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1016/j.caeai.2021.100017

[5] M. Marienko, Y. Nosenko, A. Sukhikh, V. Tataurov, and M. Shyshkina, "Personalization of learning through adaptive technologies in the context of sustainable development of teachers' education", *E3S Web Conf.*, vol. 166, p. 10015, 2020. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1051/e3sconf/202016610015

[6] E. Unamba, O. Onome, I. Daniella, and O. Adaugo, "Developing entrepreneurship skills among pre-service teachers through learning of mathematics education for sustainable development", *Int. J. Adv. Academic Res.*, pp. 238–246, 2015. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.46654/ij.24889849.s61017

[7] L. F. Daghestani, L. F. Ibrahim, R. S. Al-Towirgi, and H. A. Salman, "Adapting gamified learning systems using educational data mining techniques", *Comput. Appl. Eng. Educ.*, vol. 28, no. 3, pp. 568–589, Mar. 2020. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1002/cae.22227

[8] D. D. Kem, "Personalised and Adaptive Learning: Emerging Learning Platforms in the Era of Digital and Smart Learning", *Int. J. Social Sci. Human Res.*, vol. 05, no. 02, Feb. 2022. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.47191/ijsshr/v5-i2-02

[9] S. L. Thomas and L. M. McKenzie, "Ten Years After: The Development of a University Staff Pay System—Reflections and the Lessons Learned", *Compensation & Benefits Rev.*, vol. 51, no. 1, pp. 27–43, Jan. 2019. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1177/0886368719863521

[10] C.-C. Lin, A. Y. Q. Huang, and O. H. T. Lu, "Artificial intelligence in intelligent tutoring systems toward sustainable education: a systematic review", *Smart Learn. Environ.*, vol. 10, no. 1, Aug. 2023. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1186/s40561-023-00260-y

[11] D. Dellermann, A. Calma, N. Lipusch, T. Weber, S. Weigel, and P. Ebel, "The Future of Human-AI Collaboration: A Taxonomy of Design Knowledge for Hybrid Intelligence Systems", in *Hawaii Int. Conf. System Sci.*Hawaii Int. Conf. System Sci., 2019. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.24251/hicss.2019.034

[12] P. Gupta and S. Yadav, "A TAM-based Study on the ICT Usage by the Academicians in Higher Educational Institutions of Delhi NCR", in *Lecture Notes on Data Engineering and Communications Technologies*. Singapore: Springer Nature Singap., 2022, pp. 329–353. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1007/978-981-16-9113-3_25

[13] A. Alam, "Should Robots Replace Teachers? Mobilisation of AI and Learning Analytics in Education", in *2021 Int. Conf. Advances Comput., Communication, Control (ICAC3)*, Mumbai, India, Dec. 3–4, 2021. IEEE, 2021. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1109/icac353642.2021.9697300

[14] Y. Tsekhmister, "War, education and development: a pedagogical response to the challenges of modernity," *Academia*, no. 35-36, pp. 1-8, 2024. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.26220/aca.4999

[15] A. Alnajim, "Transformation of Education System in Saudi Arabia through Artificial Intelligence", *SSRN Electron. J.*, 2023. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.2139/ssrn.4362152

[16] O. Yuriy, L. Holomb, L. Konovalova, V. Vivsyannuk, and Y. Tsekhmister, "Assessment of the impact of artificial intelligence technologies on the development of Ukrainian medicine in war conditions," 2023. Accessed: Feb. 7, 2025 [Online]. Available: https://www.iscientific.org/wp-content/uploads/2023/11/26-ijcbs-23-24-5-26-done.pdf

[17] F. Kamalov, D. Santandreu Calonge, and I. Gurrib, "New Era of Artificial Intelligence in Education: Towards a Sustainable Multifaceted Revolution", *Sustainability*, vol. 15, no. 16, p. 12451, Aug. 2023. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.3390/su151612451

[18] Guan, J. Mou, and Z. Jiang, "Artificial intelligence innovation in education: A twenty-year data-driven historical analysis", *Int. J. Innov. Stud.*, vol. 4, no. 4, pp. 134–147, Dec. 2020. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1016/j.ijis.2020.09.001

[19] Kumar, A. Haque, K. Mishra, F. Islam, B. Kumar Mishra, and S. Ahmad, "Exploring the Transformative Role of Artificial Intelligence and Metaverse in Education: A Comprehensive Review", *Metaverse Basic Appl. Res.*, vol. 2, p. 55, Jun. 2023. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.56294/mr202355

[20] S. H. Mian, B. Salah, W. Ameen, K. Moiduddin, and H. Alkhalefah, "Adapting Universities for Sustainability Education in Industry 4.0: Channel of Challenges and Opportunities", *Sustainability*, vol. 12, no. 15, p. 6100, Jul. 2020. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.3390/su12156100

[21] I. Krasnoshchok, T. Kravtsova, L. Zahorodnia, O. Kravchuk, and I. Savelchuk, "Assessment of the Impact of Socio-Cultural Risks of Soft Skills Formation in Different Educational Environments for SDG'S", *Jlsdgr*, vol. 4, no. 2, p. e02164, Aug. 2024. DOI: https://doi.org/10.47172/2965-730X.SDGsReview.v4.n02.pe02164

[22] S. Fedushko and T. Ustyianovych, "Predicting Pupil's Successfulness Factors Using Machine Learning Algorithms and Mathematical Modelling Methods", in *Advances in Computer Science for Engineering and Education II*. Cham: Springer Int. Publishing, 2019, pp. 625–636. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1007/978-3-030-16621-2_58

[23] F. Martin, Y. Chen, R. L. Moore, and C. D. Westine, "Systematic review of adaptive learning research designs, context, strategies, and technologies from 2009 to 2018", *Educational Technol. Res. Develop.*, vol. 68, no. 4, pp. 1903–1929, Jun. 2020. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1007/s11423-020-09793-2

[24] R. Palau, M. Fuentes, J. Mogas, and G. Cebrián, "Analysis of the implementation of teaching and learning processes at Catalan schools during the Covid-19 lockdown", *Technol., Pedagogy Educ.*, vol. 30, no. 1, pp. 183–199, Jan. 2021. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1080/1475939x.2020.1863855

[25] V. J. Owan, K. B. Abang, D. O. Idika, E. O. Etta, and B. A. Bassey, "Exploring the potential of artificial intelligence tools in educational measurement and assessment", *Eurasia J. Math., Sci. Technol. Educ.*, vol. 19, no. 8, Aug. 2023, Art. no. em2307. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.29333/ejmste/13428

[26] C. G. Demartini, L. Sciascia, A. Bosso, and F. Manuri, "Artificial Intelligence Bringing Improvements to Adaptive Learning in Education: A Case Study", *Sustainability*, vol. 16, no. 3, p. 1347, Feb. 2024. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.3390/su16031347

[27] V. Ihnatiev, O. Patlaichuk, O. Stupak, A. Bobryk, H. Moskalyk, and A. Shymanovych, "The Use of S. Khoruzhyi's Ideas of Energetic Heychasm in the Educational Strategies of Postmodern Society", *Rev.*

Romaneasca Pentru Educ. Multidimens., vol. 16, no. 1, pp. 591–607, Mar. 2024. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.18662/rrem/16.1/839

[28] A. D. Sutomo, F. Nurhasanah, S. Marmoah, Sumardi, K. Saddhono, and S. S. Rahardjo, "Adaptation of Change in the Learning System with the use of Artificial Intelligence to Ensure Better Strategy", in *2024 4th Int. Conf. Advance Comput. Innovative Technol. Eng. (ICACITE)*, Greater Noida, India, May 14–15, 2024. IEEE, 2024, pp. 912–917. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1109/icacite60783.2024.10616824

[29] A. Ezzaim, A. Dahbi, A. Aqqal, and A. Haidine, "AI-based learning style detection in adaptive learning systems: a systematic literature review", *J. Comput. Educ.*, Jun. 2024. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1007/s40692-024-00328-9

[30] B. I. Chigbu, I. Umejesi, and S. L. Makapela, "Adaptive Intelligence Revolutionizing Learning and Sustainability in Higher Education", in *Implementing Interactive Learning Strategies in Higher Education*. IGI Glob., 2024, pp. 151–176. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.4018/979-8-3693-3559-8.ch006

[31] W. Strielkowski, V. Grebennikova, A. Lisovskiy, G. Rakhimova, and T. Vasileva, "AI-driven adaptive learning for sustainable educational transformation", *Sustain. Develop.*, Oct. 2024. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.1002/sd.3221

[32] Y. V. Tsekhmister, A. V. Chalyi, and K. A. Chalyy, "Teaching and Learning of Medical Physics and Biomedical Engineering in Ukrainian Medical Universities", in *IFMBE Proceedings*. Berlin, Heidelberg: Springer Berl. Heidelb., 2009, pp. 383–384. Accessed: Apr. 1, 2025. [Online]. Available: https://doi.org/10.1007/978-3-642-03893-8_110

[33] S. Kubitskyi, V. Saienko, V. Demianiuk, and K. Mykhasiuk, "Management of pedagogical and sports educational institutions in Ukraine", *SPORT TK-Revista Euroam. Cienc. Del Deporte*, p. 19, Sep. 2022. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.6018/sportk.538991

[34] V. Spitsyn, I. Antonenko, O. Synkovska, L. Dzevytska, and L. Potapiuk, "European Values in the Ukrainian Higher Education System: Adaptation and Implementation", *J. Curriculum Teaching*, vol. 13, no. 3, p. 102, Jul. 2024. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.5430/jct.v13n3p102

[35] L. Savchenko, O. Goncharova, I. Zaytseva, L. Polishchuk, I. Krasnoshchok, and N. Gramatyk, "Management of the development of the role position of future educators in higher education institutions", *Int. J. Adv. Res. Eng. Technol. (IJARET)*, vol. 11, no. 5, pp. 399–408, 2020. [Online]. Available: https://iaeme.com/Home/journal/IJARET

[36] Z. Wen, A. Shankar, and A. Antonidoss, "Modern Art Education and Teaching Based on Artificial Intelligence", *J. Interconnection Netw.*, p. 2141005, Jun. 2021. Accessed: Feb. 11, 2025. [Online]. Available: https://doi.org/10.1142/s021926592141005x

[37] A. de la Garza, "Internationalizing the Curriculum for STEAM (STEM + Arts and Humanities): From Intercultural Competence to Cultural Humility", *J. Stud. Int. Educ.*, p. 102831531988846, Nov. 2019. Accessed: Feb. 11, 2025. [Online]. Available: https://doi.org/10.1177/1028315319888468

[38] A. Devadze and B. Gechbaia, "Using Virtual Reality in the Educational Process to Increase Students' Motivation and Interest", E-Learn. Innov. J., vol. 2, no. 2, pp. 21–35, Sep. 2024. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.57125/elij.2024.09.25.02

[39] C. Bingham, "Education and Artificial Intelligence at the Scene of Writing: A Derridean Consideration", Futur. Philos., vol. 3, no. 4, pp. 34–46, Sep. 2024. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.57125/fp.2024.12.30.03

[40] R. Vainola, “Evaluating the Effectiveness of Social Media as a Means of Strengthening Family Values Among Young People”, Futurity Social Sci., vol. 2, no. 4, pp. 24–38, Sep. 2024. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.57125/fs.2024.12.20.02

[41] P. M. S., “Personalized Ontology-Based Adaptive E-Learning System”, in *Machine Learning Approaches for Improvising Modern Learning Systems*. IGI Glob., 2021, pp. 18–49. Accessed: Feb. 7, 2025. [Online]. Available: https://doi.org/10.4018/978-1-7998-5009-0.ch002