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Optimisation of Learning and Development of Cognitive Skills through the Use of Integrated Technologies of Virtual Reality and Artificial Intelligence among Students

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Abstract: Considering the innovative development of education, introducing various technologies has become an urgent issue. One of them is virtual reality and artificial intelligence technologies, which can potentially form an innovative, personally oriented space. This article aims to determine the role of integrated VR and AI technologies in optimising learning and forming cognitive skills. For this purpose, a survey was conducted among 25 teachers and 176 students (201 participants). All of them were previously trained in an integrated system of technologies, which involved AI and VR. The selection of persons is purposeful. All participants were previously familiar with the use of technology. The primary research tool is a questionnaire. The questionnaire was designed to understand these technologies' frequency of use and effectiveness. Separate questions were formed on a Likert scale (from 1 to 5). Excel software was used for data processing and analysis. The results demonstrate these technologies' effectiveness in optimising the learning space. It is also emphasised that they ensure the implementation of training based on a person-oriented approach and contribute to developing practical skills. In addition, these tools also affect the formation of critical thinking, skills of analysis, synthesis, spatial representation, attention, etc. The conclusions emphasise the importance of using these technologies to form cognitive skills. Separate recommended solutions regarding their further use are also proposed, particularly the creation of special technological departments for quick response to technical problems and the implementation of additional digital qualifications for teachers.

Keywords: digitalisation of education, perspectives, innovations, efficiency, survey.

Introduction

Modern technologies have influenced the development of the education system as a whole. They have made learning more accessible, economical and interactive, which has generally influenced the motivation of education seekers to acquire knowledge. Modern scientists who have investigated various issues of using innovations in education have proven that the active integration of advanced technologies becomes an essential tool for the system of improving the



learning process and developing cognitive skills among students (Haleem et al., 2022; Yilmaz & Karaoglan Yilmaz, 2023). In particular, a number of modern studies have determined that the widespread use of virtual reality (VR) and artificial intelligence (AI) contributes to the formation of various interactive learning environments (Yang et al., 2021). At the same time, it is also determined in the scientific field that these technologies contribute to more effective acquisition and assimilation of theoretical and practical knowledge (Krap et al., 2024; Malchenko et al., 2021; Zhang et al., 2020). At the same time, these technologies also contribute to developing analytical and critical thinking, creativity, and digital skills, which are mainly in demand in the modern labour market.

Research Problem

As can be seen from the previous brief analysis of individual scientific studies, modern innovative technological solutions provide a wide range of opportunities for optimising the educational process as they adapt educational materials to the individual needs of each student. At the same time, it should be determined that the synthesis of VR and AI in educational programs affects the formation of simulations of real situations, which in some educational situations are challenging to reproduce in traditional conditions. This, in turn, can help students better understand complex concepts and develop practical skills. In particular, technologies based on artificial intelligence allow you to actively monitor students' progress, which generally significantly optimises knowledge acquisition. Such technologies contribute to academic success and the development of cognitive and digital abilities, which are mainly in demand in today's labour market. Therefore, this research problem is particularly relevant in modern scientific discourse and will contribute to the emergence of new knowledge on this complex issue.

Research Focus

The main focus of this work will be the analysis of the features of the use of integrated technologies of artificial intelligence and virtual reality. In addition, the fundamental role of these tools in the system of learning optimisation will also be clarified, that is, whether these technologies contribute to improved knowledge acquisition for education students. Also, considering the potential of these tools, it is worth paying attention to the discovery of new directions for using artificial intelligence and virtual reality in modern innovative education.

Research Aim and Research Questions

This work analyses the possibilities of optimising training using integrated artificial intelligence technologies and virtual reality. In addition, will special attention be paid to their role in developing cognitive functions for students? Accordingly, the research questions are as follows:

1. Does the integration of AI and VR contribute to the optimisation of the learning environment?



2. Do these technologies affect the development of students' cognitive skills?

Literature Review

This literature review aims to characterise the theoretical basis of this study and identify the issues that have already been researched and those that have not been researched. Accordingly, by analysing theoretical concepts, it is possible to get a general idea of the state of research on the peculiarities of integrative technologies implementation. Modern authors have demonstrated the broad possibilities of using modern innovative technologies (Chick et al., 2020). It has been proven in scientific works that well-planned, innovative, and technological solutions contribute to the availability and speed of obtaining knowledge (Domingo & Bradley, 2017; Ergüzen et al., 2021). In particular, remote electronic technologies make obtaining knowledge from any location possible. In particular, according to research by Abumalloh et al. (2021), virtual laboratories are essential for learning in crisis situations. These authors analysed the significance of these technologies during the COVID-19 pandemic. Al-Ansi et al. (2023) developed recommendations for using virtual and augmented reality technologies in modern higher education. At the same time, the study of Arici et al. (2019) presents modern research trends in the use of augmented reality technologies. These works are essential for this study because they present a broad theoretical base for the study of virtual reality technologies. Atta et al. (2022) demonstrated that virtual reality is necessary for training students whose future professions will be technology-related. In particular, these authors demonstrated how to train students studying astronomy and space sciences.

At the same time, Bashabsheh et al. (2019) also emphasised the importance of implementing virtual reality in training specialists in architectural pedagogy. Cho et al. (2020) characterised the role of augmented reality to support practice-oriented learning based on new technological solutions. Scientists demonstrated the importance of specific virtual reality applications to support practice-oriented learning. At the same time, in the work of Celik (2023), based on an empirical study, the attitude of teachers toward artificial intelligence technologies was characterised. In addition, this researcher also described modern teachers' knowledge of AI. Other authors, particularly Chaiyarak et al. (2021), also addressed a similar question. However, these authors analysed the role of virtual platforms to ensure quality education in the university. Chen et al. (2020a) conducted a multi-complex study of artificial intelligence technologies used in education and during research, the formation of grant projects, etc. The study by Chen et al. (2020b) describes the necessary theoretical foundations for using artificial intelligence in education.

In addition, Cortiz and Silva (2017) characterised the features of using web applications and virtual platforms in the education system. The authors have proven that they significantly improve knowledge acquisition for modern students. However, modern authors have also drawn attention to specific ethical issues of using AI in the education system. In particular, the study by Dai et al. (2023) discusses this issue quite extensively.



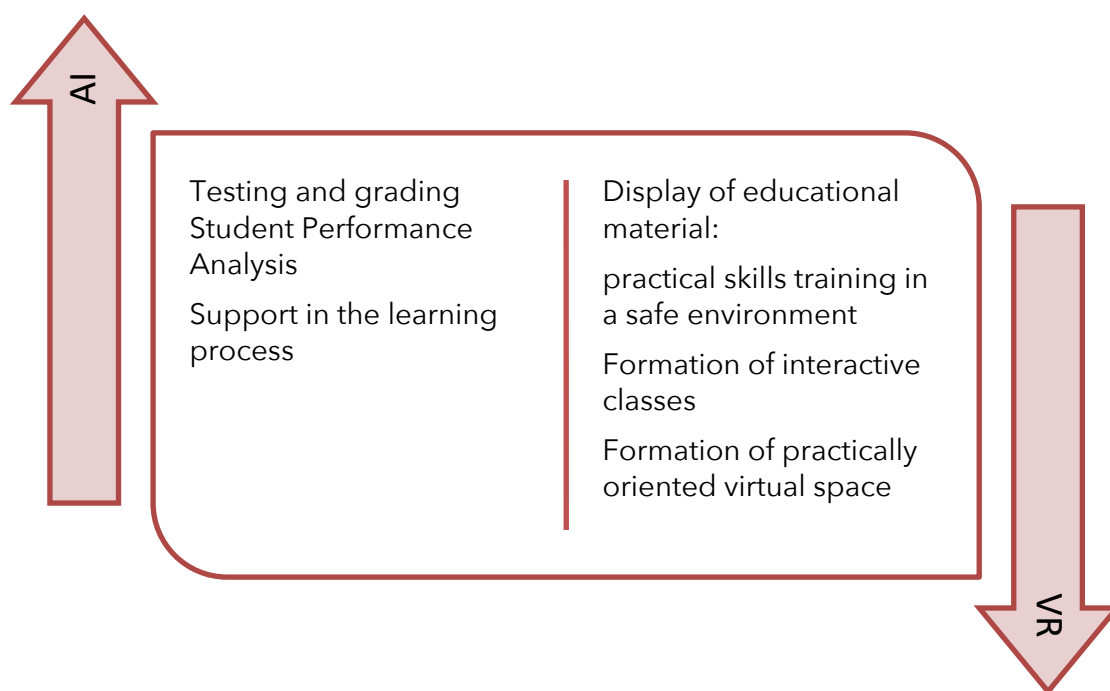
Therefore, modern authors have discussed various aspects of using artificial intelligence and virtual reality technologies. However, as can be seen from this analysis, very few works are devoted to integrating these technological innovations. This relevant question will be attempted to be resolved by this study by conducting an empirical study. However, contemporary authors have focused mainly on analysing a single technology, which is essential on the one hand. However, few comprehensive studies describe several technologies. This study will address these gaps and describe the impact of integrated technologies on learning and cognitive skills.

Materials and Methods

This research belongs to quantitative works. In particular, with the help of the questionnaires, the initial space will be optimised using virtual reality and artificial intelligence integration. Integrating these technologies provided teachers with the alternate use of these tools. Teachers were free to use these alternatives and technologies according to the topic or the need to organise the learning space. Figure 1 presents common cases where these technologies should be used under this system. However, teachers were also able to use these tools simultaneously.

Figure 1

Scheme of Implementation of the Integration Process of AI and VR Technologies



Source: Author's development.

Sample and Participants

Teachers (25 people) who actively implemented the system of integrating virtual reality and artificial intelligence technologies were invited to participate in the study. The type of sampling is purposive. Teachers from universities and technical schools were purposefully invited to



participate in this experiment; emphasis was placed on technical and medical specialities. The main criterion for selecting teachers was their ability to work with modern technologies and understand their potential (see Table 1).

Table 1

Representative Data on Teachers

Work experience	More than 1 year	More than 5 years	More than 10 years	More than 20 years
%	20%	40%	28%	12%
Ability to use technology	Used for more than 1 year	More than 2 years	More than 5 years	More than 10 years
%	16%	40%	32%	12%
Specialties	Humanitarian disciplines	STEAM and technology	Art	Medicine
%	12%	40%	12%	36%

Source: Author's development.

Students whose education was based on integrating these technologies also tested this system. The participants were from leading universities and colleges. The main criterion for the sample was also the ability to use these technologies in the knowledge acquisition system. A total of 176 students who studied under this integrated system participated.

Table 2

Representative Data of Students

Educational institution	Universities	Colleges		
%	46%	54%		
Specialties	Humanitarian disciplines	STEAM and technology	Art	Medicine
%	12%	43%	14%	31%

Source: Author's development.

In total, 201 participants took part in the study: 25 teachers and 176 students with experience working and studying on the basis of modern technologies.

Instruments and Procedures

The research procedure was step-by-step and systematic. In particular, a system of integrating these technologies was first developed and proposed for use by selected teachers. After that, teachers conducted six months of student training based on this system, which was implemented during the second academic semester. After that, a student survey was carried out



using a questionnaire designed to determine the level of learning optimisation using this integrated system.

The questionnaire was designed to understand these technologies' frequency of use and effectiveness. It involved receiving answers from all study participants: teachers and students. It contained both open and closed questions. Separate questions were formed on a Likert scale, where the number 1 meant disagreement with the statement or low efficiency of technologies, and the number 5 meant full agreement with the statement and very high efficiency of these technologies (See Table 3).

Table 3

The Questionnaire

Use of technologies	Which of the following technologies did you mostly use? 1. Artificial intelligence 2. Virtual reality 3. Both
Frequency	How many days a week did you use these technologies?
Determination of efficiency	Evaluate the impact of virtual reality on the learning process. (from 1 to 5) Rate the impact of artificial intelligence on the process of acquiring knowledge (from 1 to 5)
Impact on cognitive skills	Did the use of virtual reality affect the formation of cognitive skills (analytical and critical thinking, spatial perception, communicative functions, digital skills)? (Rate from 1 to 5) Has the use of artificial intelligence affected the formation of cognitive skills? (Rate from 1 to 5)
General ideas	What is the role of AI and VR in supporting the education system? What are the problems in using a system of integrated technologies?

Source: Author's development.

Data Analysis

After receiving the answers, their analysis was carried out. In particular, all received answers are entered in Excel tables. In particular, a table was first created with such sections as "general answers", "open answers", and "Likert scale". Then, the data was clarified; in particular, such sections as "frequency of use", "efficiency", "advantages", "and disadvantages" were formed. This made it possible to systematise the received data and carry out their analysis. Based on the synthesis method, these topics were combined, and general ideas about the role of the technologies selected for analysis were made. Summarisation of the obtained data was carried out with the help of generalisation. After that, a comparative analysis was used, which made it possible to compare the obtained data with the results presented in other scientific works.



Results

In the proposed technology integration system, the educational process participants mainly used both artificial intelligence and virtual reality (61.19%). However, artificial intelligence was preferred in teaching humanities (16.92%), while virtual reality (21.89%) was used in training medical specialists. In the integrated system, the use of these technologies was regular. In particular, survey participants noted that, as a rule, they used them several times a week (44.28%) and daily (38.31%). At the same time, 15.92% of respondents alternately used these technologies several times a month. 1.49% - once a month. Generally, it indicates a high technological level of the formed educational space (see Table 4).

Table 4

Frequency of use of Integrated Technologies

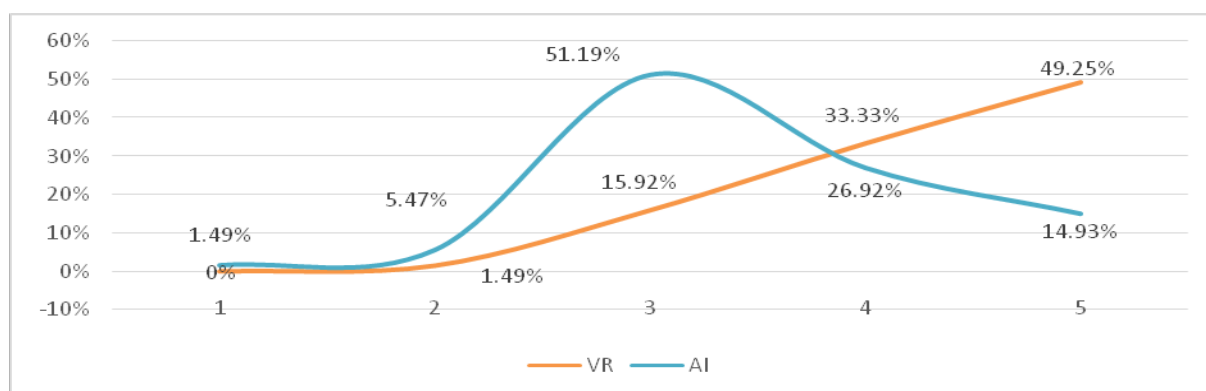
Frequency	Number of responses	%
Daily	77	38,31%
Several times a week	89	44,28%
Several times a month	32	15,92%
Once a month	3	1,49%

The use of virtual reality has significantly affected the process of acquiring knowledge. In particular, this technology can increase the involvement of students and their motivational level to acquire knowledge, as it makes the initial process more interactive and innovative (Zhang & Aslan, 2021). At the same time, it also makes it possible to develop practical skills, as it helps to visualise abstract and difficult-to-understand concepts. At the same time, artificial intelligence technologies make acquiring knowledge more personally oriented (Plotzky et al., 2021). Thanks to these technologies, teachers were able to monitor student progress closely. The participants of the educational process, in general, highly rated the effectiveness of virtual reality technologies (5 points – 49.25%; 4 points – 33.33%) and moderately the capabilities of artificial intelligence (3 points – 51.19%). This may be because the latter is just entering the market of educational services and is not yet fully developed and perfected.



Figure 2

Assessment of the Effectiveness of the Use of VR and AI on the Learning Process (Based on Grades 1-5)

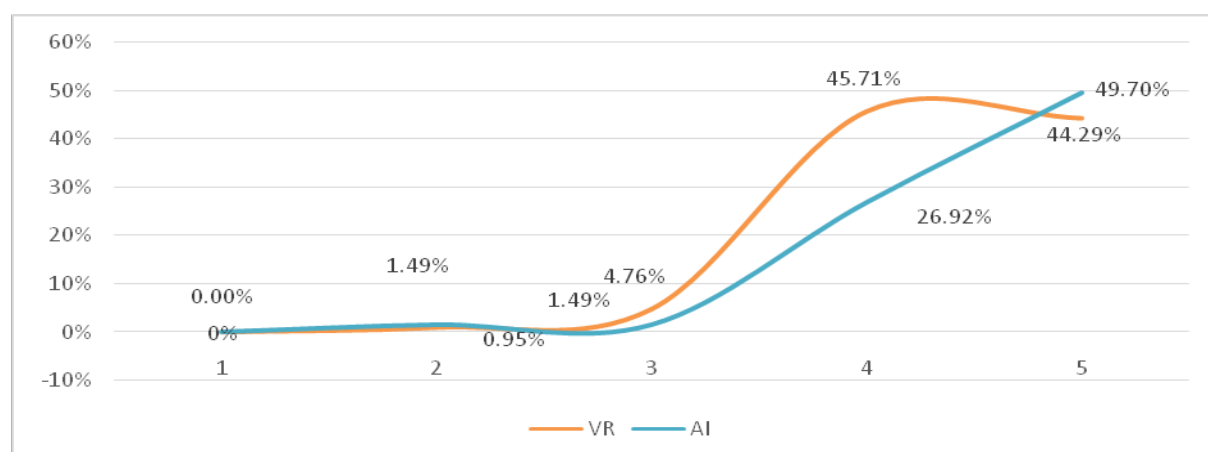


Source: Author's development.

At the same time, the widespread use of virtual reality has affected the formation of cognitive skills (Potkonjak et al., 2016). In particular, these technologies affect the development of analytical and critical thinking, spatial perception, and communicative functions (Hwang & Chien, 2022). In addition, virtual reality contributes to forming precise coordination movements and cognitive functions that imitate real situations. At the same time, they also ensure the development of digital literacy, which is currently in particular demand in the labour market. On the other hand, artificial intelligence can also potentially develop cognitive skills. Artificial intelligence contributes to the adaptation of training, analyses the students' educational results, and makes it possible to perform individual educational tasks. Also, artificial intelligence tools (for example, simulations or algorithms for data analysis) make it possible to develop critical thinking in applicants. The experiment participants highly appreciated the possibilities of these technologies for developing cognitive skills (see Figure 3).

Figure 3

The Possibilities of AI and VR for the Development of Cognitive Skills



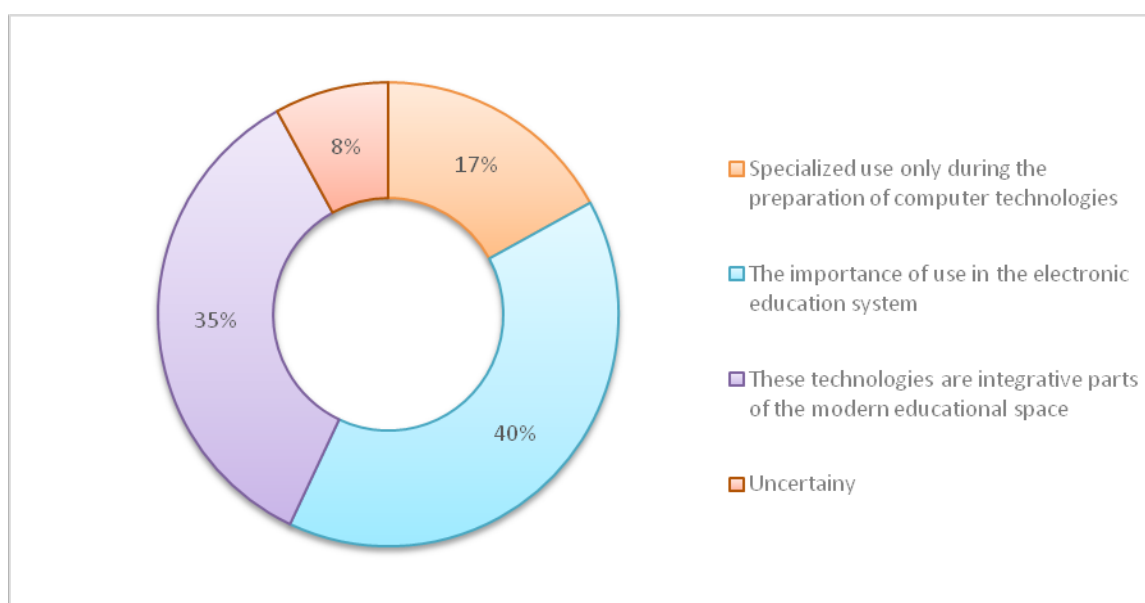
Source: Author's development.



The next stage of the research was to discover the role of these technologies in developing an innovative educational environment. In particular, most respondents emphasised the special importance of implementing these tools for developing e-education directly (40%). At the same time, 35% recognised that virtual reality and artificial intelligence should be implemented in the traditional education system and recognised these technologies as an integrated part of modern education. Another 17% emphasised that these technologies are critical when training computer technology specialists. However, another 8% found it challenging to characterise the prognostic role of these tools (see Figure 4).

Figure 4

Value of VR and AI in Contemporary Education Systems



Source: Author's development.

Thus, the use of AI and VR technologies in modern education has great potential (Nazari et al., 2021; Winkler-Schwartz et al., 2019). However, their use may face various problems. In particular, these technologies are high-cost; therefore, the wide use of their capabilities cannot be inherent in all educational institutions. There may also be technical issues, including slow internet speed (or no internet). Also, to maximise the use of these tools, all participants in the educational process must have high-speed computers. There is also a need for additional technical support for teachers. An information and technical department should be formed in modern institutions that use these technologies to deal with technical problems quickly. In addition, there are currently no general standards for using artificial intelligence in education, which creates additional obstacles to its widespread implementation.

Discussion

Digitisation of education at the current stage is a challenge both in organisational and instrumental terms. The purpose of the proposed article was to investigate the possibilities of



optimising learning due to the use of integrated technologies of artificial intelligence and virtual reality. It was proposed to investigate to what extent the integration of AI and VR contributes to the optimisation of the educational environment and how the proposed technologies affect students' cognitive skills development. In the proposed results, it was noted that the participants of the educational process mainly used both artificial intelligence and virtual reality (61.19%). However, such applications depended on the fields: artificial intelligence was more famous for humanitarian disciplines, and virtual reality for exact (medical) specialities. This confirms the conclusions of other scientists that the integration of modern digital technologies takes place according to the discipline and direction of study, adapting in an appropriate way to the needs of the educational process (de Moraes Rossetto et al., 2022; Kozlovskiy et al., 2024; Pottle, 2019). The proposed study also showed that, in general, AI and VR technologies were used frequently – either several times a week or daily. This also confirms the empirical results of the work of other researchers, who note the high level of technology in the modern educational space (Laupichler et al., 2023). Such trends will be relevant shortly when the integration of digital techniques only intensifies.

In the proposed results, it is noted that virtual reality has a tangible effect on knowledge acquisition. First, we discuss the possibility of increasing motivation and developing practical skills, as it helps visualise abstract and difficult-to-understand concepts. Artificial intelligence technologies make the process of acquiring knowledge more personally oriented. In the results, it was noted that the effectiveness of virtual reality was rated higher than the capabilities of artificial intelligence. It is probably worth agreeing with researchers who consider AI capabilities insufficiently integrated with modern educational platforms: usually, teachers use artificial intelligence autonomously, without integration with other educational technologies (Hwang et al., 2020; Ouyang & Jiao, 2021). Thus, it can be assumed that the potential possibilities of AI have not yet been revealed, and it has only just appeared in the educational services market. At the same time, one cannot agree with scientists' predictions that AI's future in education is uncertain and its components are more harmful because they allow cheating during learning (Memarian & Doleck, 2023). First of all, it is worth supporting the opinion that with the current state of technology, independent learning through AI is impossible (Somasundaram et al., 2020), and the presence of teachers will not allow you to cheat forever. At least, it is already quite evident that artificial intelligence has become part of the educational space, and its function will evolve in the future.

In the proposed results, it was noted that virtual reality influenced the formation of cognitive skills. In particular, these technologies affect the development of analytical and critical thinking, spatial perception, and communicative functions. In addition, virtual reality was highly appreciated for forming precise coordination movements and cognitive functions that imitate real situations. On the other hand, artificial intelligence makes it possible to develop cognitive skills, adapt training, and analyse students' educational results. The obtained results generally confirm other empirical measurements of scientists regarding this process, which noted the high potential of these technologies for developing cognitive skills (Kamińska et al., 2019; Volioti et al., 2022). It



is worth noting the unanimity of the opinions of scientists in this regard. However, the digital evolution may require additional evaluations since it is incomplete.

Also, as shown in the proposed study, it is imperative to implement these tools to develop electronic education. It is worth agreeing with researchers that artificial intelligence and virtual reality technologies are at the forefront of integration with modern education (Bobro, 2024; Dai et al., 2023; Petersen et al., 2022). At the same time, the study noted challenges regarding their use: the high cost of implementation, technical problems and the need for high-speed computers, additional technical support for teachers, and the need for common standards for using artificial intelligence. The list of such challenges generally coincides with the results of other scientists (Southworth et al., 2023; Villena-Taranilla et al., 2022). At the same time, such a list is far from exhaustive: some scientists, for example, pay attention to the importance of the necessary level of digital competence (Garzón et al., 2020). Although, in most cases, such a need is not critical today, it is possible that with the complexity of working with virtual reality and artificial intelligence, such needs will become relevant.

The proposed research methodology had certain limitations. In particular, using a "Likert scale" is associated with specific problems, considering respondents with different points can evaluate the same phenomenon according to their life experience and degree of sensitivity to the issue. With this in mind, it is possible to adjust specific results, which will not constitute a radical revision in the obtained data.

Conclusions and Implications

Therefore, integrating artificial intelligence and virtual reality technologies is alternating and should be used several times weekly. These technologies have vast opportunities for developing cognitive skills: critical thinking, spatial perception, the ability to analyse, synthesise, abstract thinking, and develop logic. In addition, they also affect the speed of information processing in today's digital world. At the same time, these intelligence technologies make acquiring knowledge more personally oriented. Thanks to these technologies, teachers could closely monitor students' progress. All participants in the educational process highly appreciated the effectiveness of virtual reality technologies and the capabilities of artificial intelligence. Therefore, these technologies have the potential to develop further in the modern education system. Recommendations for their further use include such points as:

1. Develop a special department for digital support of educational institutions to respond quickly to technical problems.
2. Digital training of teachers due to their participation in various scientific projects and qualification development courses.



Suggestions for Future Research

The proposed topic has a relatively high scientific potential for the formation of further generalisations. First, we are considering the constant digital evolution, which offers new challenges and perspectives for applying VR and AI. In particular, we are talking about creating training programs with an individualised trajectory that would consider the student's knowledge level and cognitive abilities. Under such circumstances, the individualisation of learning would reach new markers of effectiveness, requiring further evaluation. Further research can also be devoted to the impact of virtual reality and artificial intelligence on the health of education seekers. This issue will still require a balanced assessment since the impact of these technologies on attention, memory, creativity, and the formation of critical thinking has not yet been measured. It is also necessary to consider the specifics of forming social skills such as cooperation, communication, emotional intelligence, and empathy in learning environments that constantly use AI and VR. Separately, it is worth emphasising the importance of combining digital mechanisms with traditional education, as it is already clear today that we are discussing the combination of these systems, not their parallel existence. Under such circumstances, the indicated issues will require more attention and further scientific research. The proposed perspectives are not exhaustive but indicate the urgency of further developing this issue. Further development of this topic will make it possible to significantly increase the effectiveness of training and the development of cognitive skills among students.

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Conflict of Interest

None.

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