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THE USE OF VIRTUAL REALITY HARDWARE AND SOFTWARE COMPLEXES IN THE PROFESSIONAL TRAINING OF COMPUTER SCIENCE TEACHERS: STRATEGIES AND PERSPECTIVES FOR THE DIGITALIZATION OF THE EDUCATIONAL PROCESS

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Abstract

Relevance The necessity of analyzing the use of virtual and augmented reality hardware and software complexes in the professional training of computer science teachers under the conditions of educational digitalization is driven by the need for a profound understanding of the opportunities and challenges these technologies create for modern pedagogical practice. Such an analysis enables the assessment of the effectiveness of VR/AR tools in forming the professional, methodological, and digital competencies of future teachers, determining their level of readiness to work with immersive technologies, and outlining optimal strategies for implementing these innovations into the educational process. In the context of the digital transformation of education, such research is essential to ensure the scientifically grounded implementation of VR/AR in pedagogical personnel training, enhancing the quality of education, and adapting the educational environment to the requirements of the modern information society.

*Purpose***:** to substantiate the theoretical and methodological foundations of implementing VR/AR technologies in teacher training as a factor in developing their digital and professional competence.

*Methods***:** analysis, synthesis, systematization, generalization, observation, survey, comparative-analytical method, and modeling.

*Results***:** showed that immersive technologies create an interactive educational environment in which future computer science teachers develop cognitive, emotional, and communicative skills. International experience (China, Norway, the EU, the USA, Japan) was investigated, proving the effectiveness of VR/AR as a tool for active learning, modeling pedagogical situations, and improving the quality of knowledge acquisition. It is demonstrated that the implementation of such technologies requires pedagogical support, methodological dosage, and technical provision. It is recommended to integrate VR/AR into teacher training programs as a component of the digital transformation of education. Furthermore, key stages of implementing virtual technologies into the professional education system were identified, encompassing the adaptation of curricula, training of pedagogical staff, and the creation of technical infrastructure.

*Conclusions***:** the study proves that the implementation of virtual and augmented reality (VR/AR) technologies is a vital direction for the digitalization of the professional training of computer science teachers; they contribute to the development of digital competence, professional thinking, communicative and emotional skills, create an interactive educational environment, and increase motivation for learning; international experience confirms the effectiveness of VR/AR as tools for modernizing education and forming a new pedagogical culture.

Keywords: *virtual reality, digitalization, teacher training, VR/AR, education.*

Introduction. The current state of educational development is characterized by intensive digitalization, which leads to the transformation of traditional approaches to teaching and training pedagogical personnel. In the training of future informatics teachers, this process is of particular importance, as they are the primary drivers of digital innovations in the educational process. The use of virtual (VR) and augmented (AR) reality hardware and software complexes serves as an important factor in implementing the "education of the future" concept, as it contributes to the development of critical thinking, professional reflection, and the creative potential of students.

Research sources. The issue of using virtual reality hardware and software complexes in the professional training of informatics teachers, considering the strategies and prospects of the educational process digitalization, is sufficiently researched in domestic and foreign scientific literature. In modern scientific discourse, there is an active interest in the potential of VR/AR technologies as a tool for modernizing pedagogical education. In particular, a significant contribution to the study of this topic was made by Yu. Trach (Trach, 2017), who considers VR not only as a method but also as a means of forming new approaches to teaching that involve interactivity, immersiveness, and personalization of the educational experience. Also important is the position of O. Sokoliuk (Sokoliuk, 2021), who emphasizes the change in educational practices under the influence of VR/AR, highlighting the need to rethink traditional didactic models. The study by Ya. Slupska and O. Shkurenko (Slupska & Shkurenko, 2022) has a valuable practical dimension, analyzing examples of successful VR implementation in learning environments.

I. M. Romanyshyn, O. V. Samborska, and N. A. Khmil (Romanyshyn, Samborska, & Khmil, 2024) focus on the effectiveness of VR/AR as a means of professional training for educators, particularly in the context of forming professional identity and developing practical skills. N. M. Petrukha and co-authors (Petrukha, Tripak, & Fedorchuk, 2024) consider VR as a tool for developing stress resistance, which is relevant in training educators who will work with special categories of students. N. Maiatina (Maiatina & Khanykina, 2021) underscores the potential of VR/AR for improving the quality of education, drawing attention to the accessibility, adaptability, and multi-layered nature of immersive learning. A. Kovalchuk (Kovalchuk, 2023) analyzes VR in the context of the digital competence of future educators, emphasizing the necessity of a systemic approach to forming digital skills.

In turn, O. Yu. Kovalenko, D. V. Hulpa, and Ye. O. Khrinyk (Kovalenko, Hulpa, & Khrinyk, 2025) offer an overview of modern trends in implementing VR/AR in the professional training of educators in Ukraine, drawing attention to technical and methodological challenges. Foreign experience is thoroughly covered in the meta-analysis by H. Han and co-authors (Han, Luo, Wang, & Zhang, 2025), which demonstrates the effectiveness of VR in forming the professional competencies of teachers, as well as in the study by A. S. Faldet and colleagues (Faldet, Skrefsrud, Somby, & Stalheim, 2025), which presents the experience of integrating VR into the training system for future educators in Norway, with an emphasis on practice-orientation and student engagement.

H. Han, H. Luo, Z. Wang, and D. Zhang (Han, Luo, Wang & Zhang, 2025) conducted a systematic review and meta-analysis of studies from 2014–2024, demonstrating the effectiveness of using virtual reality in the professional training of teachers, particularly in aspects of pedagogical skill development. A. S. van der Want and A. J. Visscher (Van der Want & Visscher, 2024) emphasized the key characteristics of VR technologies in training future teachers, highlighting their role in modeling pedagogical situations and increasing learning motivation. O. V. Klochko, S. V. Tkachenko, I. M. Babiichuk, V. M. Fedorets, and T. V. Halych (Klochko, et al., 2021) substantiated the feasibility of integrating VR technologies into the school informatics course, which is also significant for the teacher training system, forming their readiness to use the latest digital tools in teaching.

Expert literature was also used for the research, including publications in modern online editions such as "Osvita.ua," "New Ukrainian School," "EdEra," and analytical materials from the Ministry of Education and Science of Ukraine, which highlight the current state and prospects of educational digitalization, the implementation of

VR/AR technologies in the educational process, and teacher training.

Despite the existence of a significant number of scientific works on this issue, there is a lack of systematized and generalized material. In view of this, using various methods of scientific cognition, an analysis, grouping, and systematization of information presented in the context of the research topic were carried out.

The purpose of the article is to substantiate the theoretical and methodological foundations of using virtual (VR) and augmented (AR) reality hardware and software complexes in the process of professional training for informatics teachers under the conditions of educational digitalization. To achieve this goal, the following tasks will be performed: to define the pedagogical potential of VR/AR technologies in the context of modern education; to analyze methodological approaches to integrating immersive technologies into the training of pedagogical personnel; to generalize the results of domestic and foreign research on the problem of implementing VR/AR in the educational process; to formulate promising directions for using VR/AR complexes in the professional education of informatics teachers.

Research methods: The methodological basis of the research consists of systemic, competency-based, and activity-based approaches, which ensure a comprehensive understanding of the process of implementing virtual (VR) and augmented (AR) reality hardware and software complexes into the professional training of informatics teachers. The systemic approach allows for considering the educational process as a holistic dynamic system, within which VR/AR technologies act as integrated elements of the pedagogical environment. The competency-based approach is oriented toward forming the digital, professional-pedagogical, and research competencies of future teachers, while the activity-based approach directs educational practice toward active student interaction with the immersive environment and the development of skills to analyze, model, and evaluate pedagogical situations.

In the process of the research, a complex of complementary methods was used: – theoretical methods – analysis and synthesis of scientific sources on the problems of educational digitalization, generalization of modern approaches to implementing VR/AR in pedagogical practice, and systematization of international research results; – empirical methods – observation of the educational process, analysis of pedagogical experience in implementing VR simulations and AR applications in educational institutions, and surveying students and teachers regarding the effectiveness of using immersive technologies; – comparative-analytical method – to identify common and differing trends in the use of VR/AR in domestic and foreign pedagogical education; – modeling method – to develop a conceptual model for integrating VR/AR complexes into the professional training of informatics teachers.

The scientific novelty of the methodology lies in the combination of pedagogical and technological approaches to studying VR/AR as a didactic tool that simultaneously affects the cognitive, emotional, and communicative spheres of the future educator. The methodological structure of the research is oriented toward creating conditions for understanding VR/AR not only as a technical resource but as a means of developing the personal and professional potential of the teacher in the context of the digital transformation of education.

Results and Discussion. *Theoretical aspects of implementing VR and AR in education*. Digitalization of the educational process is a fundamental factor in the development of modern pedagogical theory and practice. In the context of the professional training of informatics teachers, it acquires special significance, as it contributes to the formation of the digital competence of future educators. The use of information and communication technologies (ICT), in particular virtual (VR) and augmented (AR) reality hardware and software complexes, ensures the integration of innovative approaches into learning, increases the efficiency of the educational process, expands the didactic capabilities of the teacher, and activates the cognitive activity of learners (Kovalchuk, 2023).

Virtual (VR) and augmented (AR) reality belong to immersive technologies that create an effect of presence in a modeled digital space. They allow the user to immerse themselves in simulated environments or overlay virtual objects onto the real world, thereby expanding the boundaries of cognitive experience. In a pedagogical context, this means the possibility of creating immersion situations in which the learner acts as an active subject of cognition. Mixed reality (MR), which combines VR and AR, opens new opportunities for interactive learning, allowing for the simultaneous perception of the real environment and virtual elements that stimulate cognitive activity and

increase learning motivation (Slupska & Shkurenko, 2022).

Augmented reality (AR) technology allows for the integration of virtual 3D objects into the physical environment, creating a new learning context. Thanks to AR, a student can interact with holographic models, simulations, or animations overlaid on real objects through the screens of mobile devices or special glasses. In turn, virtual reality (VR) technology provides full user immersion into a digital environment, allowing for the reproduction of learning situations that are impossible or dangerous in physical reality. Thus, VR contributes to the formation of practical skills, the development of spatial thinking, and the understanding of complex processes through interactive simulation (Slupska & Shkurenko, 2022).

There are various types of virtual reality systems, which differ in the degree of user immersion and the method of interaction with the virtual space. These include: "Window on the World" type systems; full immersion systems, mixed reality; video mapping systems; and telepresence systems (Maiatina & Khanykina, 2021).

Each type has its own technical and didactic features. For instance, immersion systems provide the highest level of immersivity, allowing the student to experience the "presence" effect in the learning environment, while video overlay systems combine digital and physical elements, forming a virtual avatar of the user in the educational cyberspace (Maiatina & Khanykina, 2021).

The main elements of virtual reality used in education include cyberspace, three-dimensional graphics, simulations, 3D tours, and virtual panoramas. Each of these elements performs a specific function in the educational process: three-dimensional graphics – for visualizing complex concepts; simulations – for practical skill development; 3D tours – for creating educational routes; panoramas – for the sense of presence in a real environment. The application of such tools increases learning interactivity, develops visual thinking, and ensures interdisciplinary knowledge integration (Maiatina & Khanykina, 2021).

Methodological aspects of implementing VR technologies in the educational process. The effective implementation of virtual (VR) and augmented reality (AR) technologies in pedagogical education requires a methodologically sound approach. These technologies cannot be considered merely a technical novelty – they should be integrated into the educational process as a tool for developing the professional competencies of future teachers. For VR and AR to truly become effective educational means, they must be content-rich, accessible, and flexible. Primarily, immersive technologies must create a presence effect – ensuring the full immersion of the user into the virtual environment. It is this sense of "transfer" that allows the learner to study through experience, emotions, and practice (Kovalenko, Hulpa & Khrinyk, 2025).

It is essential that the implementation of VR and AR in pedagogical education is based on a holistic methodological system. It should provide for the creation of state standards, methodological recommendations, and textbooks regulating the use of the latest technologies in teacher training. The inclusion of VR/AR components in the curricula of pedagogical, methodological, and psychological disciplines is necessary. This will allow students not only to master theoretical knowledge but also to model real pedagogical situations in a safe environment. It is also important to increase the digital literacy of educators. They must become the guides for new technologies; therefore, participation in trainings, courses, and master classes is a mandatory condition for professional development. Technical support also plays a significant role – educational institutions must be equipped with VR headsets, AR devices, powerful computers, and licensed software. Without this, even the best methodology will remain theoretical (Kovalenko, Hulpa & Khrinyk, 2025).

Advantages of VR technologies in education. The results of international research confirm the high pedagogical effectiveness of VR technologies. In particular, a study by Faldet A.S., Skrefsrud T.A., Somby N.M., and Stalheim O.R. analyzed the experience of future teachers participating in VR simulations of teaching situations. Using the focus group interview method, the researchers found that immersive simulations not only increase engagement but also foster emotional resilience and reflexivity. Future teachers reported that even in a virtual environment, they experienced real emotions – anxiety, empathy, and tension. Such emotional reactions are a necessary component of a teacher's professional development. One student noted: "It's completely synthetic, but the feelings are real." Others emphasized that simulations helped them learn to stay calm in difficult situations, react thoughtfully, and control their own emotions. Such

results indicate that VR can be not only a technical teaching aid but also a powerful psychological tool for shaping pedagogical culture (Faldet, Skrefsrud, Somby & Stalheim 2025).

Participation in VR simulations stimulated the development of dialogue and cooperation among students. Post-simulation discussions helped them realize their own actions, mistakes, and successes. Observing peers became an effective way of self-directed learning, as it allowed them to see various behavioral strategies in pedagogical situations. One study participant emphasized: "We are inspired by each other." Such forms of interaction correspond to Vygotsky's ideas about the social nature of learning, where development occurs through cooperation, communication, and mutual learning (Faldet, Skrefsrud, Somby & Stalheim 2025).

The use of VR also contributes to the development of professional thinking. During interviews, students noted that simulations forced them to rethink the meaning of pedagogical concepts – support, trust, and communication. One participant admitted: "I realized that familiar words have a completely different meaning when you see them in action." Such experience deepens the understanding of pedagogical principles and contributes to the formation of the future teacher's reflexive position (Romanyshyn, Samborska & Khmil, 2024).

Virtual reality has significant potential to support learners with special educational needs, as it creates a safe, controlled, and adaptive learning environment. Due to the possibility of modeling situations, adjusting the pace of material presentation, and using multi-sensory interaction, VR promotes the development of cognitive, communicative, and socio-emotional skills of such students. Immersive technologies allow for the avoidance of stimulus overload by adjusting the difficulty level according to the child's individual capabilities. Specifically, for students with visual, hearing, or musculoskeletal impairments, VR provides alternative perception channels – through visualization, tactile, or auditory feedback. Furthermore, virtual simulations help build social interaction skills in children with autism spectrum disorders, providing an opportunity to practice behavioral reactions in a safe space. Thus, the use of VR technologies opens new opportunities for implementing the principles of inclusive education, ensuring equal access to knowledge and creating conditions for individualized learning (Petrukha, Tripak & Fedorchuk, 2024).

VR simulations have also introduced a new type of learning that goes beyond the traditional lecture model. They allow students to experiment and make mistakes without risk to real participants in the educational process. This safety promotes the free development of professional skills. One student noted: "It's good that you can make mistakes – and it's safe." Thanks to this, a culture of pedagogical flexibility is formed, where a mistake is perceived as an element of learning rather than a failure (Trach, 2017).

Table 1

Comparative table of pedagogical effects of VR simulations

Aspect of development	**Manifestation in VR simulation**
Emotional sphere	Emergence of real emotions (empathy, tension, anxiety)
Communicative competence	Dialogue and cooperation during discussions
Cognitive reflection	Analysis of one's own actions and mistakes, observation of others

Systematized by the author based on sources: Trach, 2017; Romanyshyn, Samborska & Khmil, 2024; Petrukha, Tripak & Fedorchuk, 2024; Faldet, Skrefsrud, Somby & Stalheim, 2025.

Therefore, the methodological implementation of VR and AR in pedagogical education creates conditions for a deep transformation of the learning process. It combines technological progress with psychological and pedagogical approaches aimed at developing reflection, communication skills, critical thinking, and the emotional intelligence of future teachers. Immersive technologies transform traditional education into an interactive, exploratory, and simultaneously humanistic process, at the center of which is the personality of the future educator (Trach, 2017).

Examples of using VR technologies in global educational practice. Numerous VR and AR-based applications are already being used in educational

practice. Specifically, Google Expeditions provides virtual field trips for students, Second Life creates educational simulations in a virtual world, Melchemistry helps study chemical processes, and New Horizon demonstrates a new generation of AR textbooks. Atom Visualizer and CreatorAVR allow for the visualization of scientific models and the creation of interactive educational tasks without programming. Such tools contribute to the personalization of learning, the adaptation of material to the individual needs of learners, and the formation of digital creativity competencies (Maiatina & Khanykina, 2021).

Among the projects that most successfully demonstrate the potential of VR in education, one can highlight LABSTER, which allows students to conduct virtual experiments in scientific laboratories; EXPEDITIONS PIONEER PROGRAM – for organizing virtual trips; and ER VR – for medical training in simulated clinical situations. Educational platforms like Lecture VR, Titans of Space, or Colosseum VR open possibilities for interactive study of history, astronomy, or architecture. Such systems provide high interactivity, realism, and emotional involvement, which significantly improves the quality of learning (Trach, 2017).

Today, virtual reality technologies are actively being implemented in educational practices in various countries worldwide, confirming their significant potential as a tool for modernizing learning. They are no longer an element of experimental pedagogy but are turning into an important component of innovative educational systems aimed at increasing motivation, the quality of knowledge acquisition, and the development of students' practical skills. Examples of using VR in training demonstrate a wide range of possibilities – from modeling physical processes to simulating pedagogical situations in future teacher training (Trach, 2017).

A prominent example of successful VR implementation in higher education is China. A large-scale experiment was conducted in several Chinese universities, where classrooms were equipped with HTC Vive virtual reality headsets. Experiment participants attended classes using VR applications aimed at increasing engagement and the depth of material mastery. The results were impressive: the average academic performance level of students in VR groups was 94% compared to 73% in control classes. Researchers also recorded an increase in attention span, improved memory, and a decrease in fatigue levels during classes. Thus, the Chinese experiment confirmed that virtual reality not only improves the quality of learning but also positively affects the psychological resilience of students, stimulating cognitive activity and long-term retention of material (Slupska & Shkurenko, 2022).

Significant attention to immersive technologies is also observed in European universities. In studies conducted at Leiden University (the Netherlands), VR is used in combination with augmented reality (AR) and Microsoft HoloLens technology. This tool allows medical students to study anatomy by observing a virtual model of the human body that reacts to their movements. This format of learning promotes the development of spatial reasoning, a better understanding of complex biological processes, and the safe acquisition of practical skills that would normally require long-term laboratory research. Similar VR solutions are being implemented in the educational programs of Japan Airlines, where future pilots and aircraft mechanics undergo training in simulated flight environments. They practice actions during emergencies, engine maintenance, and crew communication. This not only reduces the cost of real simulators but also increases the level of training safety (Sokoliuk, 2021).

A high level of VR application is also demonstrated by the NASA Project Sidekick program, within which HoloLens technology is used for astronaut training. Virtual simulations allow space station crews to receive step-by-step support from engineers on Earth, view instructions in real-time, and model technical situations without risking lives or equipment. This is an example of how VR can effectively combine education, engineering, and remote control, forming a fundamentally new format of learning in extreme conditions (Sokoliuk, 2021).

Furthermore, in many countries, VR and AR are increasingly integrated into general secondary education. For middle school students, free 3D visualization programs are used, including Paint 3D, Mixed Reality Viewer, and Story Remix, which are part of the Windows 10 operating system. They allow for the creation of three-dimensional objects and the modeling of chemical reactions, astronomical phenomena, or architectural structures. Such tools contribute to the development of creativity, engineering thinking, and research activity skills. Educational institutions in EU countries also actively use the VictoryVR Science

Curriculum collection of VR models and the Mozaik Education digital library, which are utilized during the study of natural sciences and mathematics. Their advantage lies in the ability to create interactive laboratory experiments that do not require physical materials but provide a realistic reproduction of experiments (Sokoliuk, 2021).

It is worth noting that the global development of VR is not limited to technical innovations; it is accompanied by methodological reflection. According to the generalized results of a meta-analysis by Han H., Luo H., Wang Z., and Zhang D., the success of VR applications in teacher education depends on three key factors: the target audience, the duration of exposure, and the level of interactivity. Research shows that VR has the best impact on novice students who are still forming their pedagogical identity. For experienced teachers, the practical orientation of the content and its alignment with curricula play a greater role. At the same time, short but repetitive VR sessions accompanied by reflection and feedback prove to be the most effective. Excessive use of the technology can lead to cognitive fatigue; therefore, methodological dosing of educational immersions is mandatory. Highly interactive simulations provide deeper engagement but require careful pedagogical support from instructors to avoid student overload (Han, Luo, Wang & Zhang, 2025).

To demonstrate how various factors—from the duration of learning to the level of interactivity—influence the effectiveness of VR learning, let us consider the generalized data from the study by Han H., Luo H., Wang Z., and Zhang D. (Table 2).

Table 2

Analytical table of VR effectiveness factors

Factor	Optimal Approach	Potential Risk
Target Audience	Novice students forming identity	Insufficient adaptation for experienced teachers
Duration of Exposure	Several short sessions (up to 45 min)	Cognitive fatigue during prolonged immersion
Interactivity Level	High sensory presence and meaningful interaction	Sensory overload

Systematized by the author based on the source: Han, Luo, Wang, & Zhang, 2025.

At the same time, the accessibility of VR and AR is no less important. Educational systems should not require complex technical skills from either instructors or students. The interface must be intuitive, and the content must be clear and pedagogically justified. Effective technologies in the field of education should tell stories, engage learners in active activities, and facilitate material mastery through interaction. Furthermore, VR/AR technologies must adapt to students' level of preparation, their interests, and their learning needs. The success of such an approach is also determined by the ability to demonstrate real results—from reflection to practical achievements that can be assessed through special tests or observations. Only under such conditions can immersive learning perform a cognitive and educational function rather than an entertaining one (Sokoliuk, 2021).

The experience of using VR in various countries confirms its effectiveness as a universal educational tool. It not only modernizes traditional approaches but also forms a new learning culture based on active research, emotional engagement, and safe experimentation. In the future, virtual reality could become the foundation of flexible, individualized education that combines technological advancements with the humanistic values of modern pedagogy.

Conclusions. Summarizing the research results, it has been established that the use of hardware-software complexes of virtual (VR) and augmented (AR) reality in the system of professional training for computer science teachers is one of the key directions of the digitalization of modern education. It is shown that these technologies integrate innovative means of cognition into pedagogical practice, contribute to the development of the digital competence of future educators, the formation of cognitive, emotional, and communication skills, and ensure the creation of an interactive educational environment in which the learner acts as an active subject of the educational process. In the course of the study, the methodological foundations for implementing VR/AR in teacher education were substantiated, combining the technological potential of the virtual

environment with humanistic principles of learning oriented toward the development of the teacher's personal and professional potential.

Investigating the practical component, it is shown that VR simulations contribute to the formation of emotional stability, reflection, professional thinking, and effective communication skills, creating conditions for safe experimentation and the modeling of pedagogical situations. Foreign experience (China, EU countries, USA, Japan, Norway) confirms the effectiveness of immersive technologies as a means of increasing motivation, the quality of knowledge acquisition, and the development of pedagogical creativity. Thus, the conducted research has allowed for the proof that VR/AR technologies are an important factor in the digital transformation of professional education, capable of forming a new pedagogical culture based on the combination of innovative technologies, emotional-cognitive experience, and learner-centered education.

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ВИКОРИСТАННЯ АПАРАТНО-ПРОГРАМНИХ КОМПЛЕКСІВ ВІРТУАЛЬНОЇ РЕАЛЬНОСТІ У ПРОФЕСІЙНІЙ ПІДГОТОВЦІ ВИКЛАДАЧІВ ІНФОРМАТИКИ: СТРАТЕГІЇ ТА ПЕРСПЕКТИВИ ЦИФРОВІЗАЦІЇ ОСВІТНЬОГО ПРОЦЕСУ

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Реферат:

Актуальність. Необхідність проведення аналізу використання апаратно-програмних комплексів віртуальної та доповненої реальності у професійній підготовці викладачів інформатики в умовах цифровізації освіти зумовлена потребою глибокого розуміння можливостей і викликів, які ці технології створюють для сучасної педагогічної практики. Такий аналіз дає змогу оцінити ефективність застосування VR/AR-засобів у формуванні професійних, методичних і цифрових компетентностей майбутніх викладачів, визначити рівень їх готовності до роботи з імерсивними технологіями, а також окреслити оптимальні стратегії впровадження цих інновацій у навчальний процес. У контексті цифрової трансформації освіти подібне дослідження є необхідним для забезпечення науково обґрунтованого впровадження VR/AR у підготовку педагогічних кадрів, підвищення якості освіти та адаптації освітнього середовища до вимог сучасного інформаційного суспільства.

Мета: обґрунтувати теоретичні та методичні засади впровадження VR/AR-технологій у підготовку педагогів як чинника розвитку їх цифрової та професійної компетентності.

Методи: аналіз, синтез, систематизація, узагальнення, спостереження, опитування, порівняльно-аналітичний метод і моделювання.

Результати: показали, що імерсивні технології створюють інтерактивне освітнє середовище, в якому майбутні викладачі інформатики розвивають когнітивні, емоційні та комунікативні навички. Досліджено зарубіжний досвід (Китай, Норвегія, ЄС, США, Японія), який доводить ефективність VR/AR як інструменту активного навчання, моделювання педагогічних ситуацій та підвищення якості засвоєння знань. Показано, що впровадження таких технологій вимагає педагогічного супроводу, методичного дозування та технічного забезпечення. Рекомендовано інтегрувати VR/AR у програми підготовки викладачів як складову цифрової трансформації освіти. Також визначено ключові етапи впровадження віртуальних технологій у систему професійної освіти, що охоплюють адаптацію навчальних програм, підготовку педагогічних кадрів і створення технічної інфраструктури.

Висновки: дослідження доводить, що впровадження технологій віртуальної та доповненої реальності (VR/AR) є важливим напрямом цифровізації професійної підготовки викладачів інформатики; вони сприяють розвитку цифрової компетентності, професійного мислення, комунікативних та емоційних навичок, створюють інтерактивне освітнє середовище й підвищують мотивацію до навчання; зарубіжний досвід підтверджує ефективність VR/AR як інструментів модернізації освіти та формування нової педагогічної культури.

Ключові слова: *віртуальна реальність, цифровізація, підготовка педагогів, VR/AR, освіта.*

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