

REFERENCES

- Dhapte, A. (2024). Immersive Technology in Education Sector Market. Available at: <https://www.market-researchfuture.com/reports/immersive-technology-in-education-sector-market-12134> (Accessed:14.11.2024). [in English].
- Burov, O., Pinchuk, O. (2022). Extended Reality in Digital Learning: Influence, Opportunities and Risks' Mitigation. *Person-oriented Approach (3L-Person 2021) co-located with 17th International Conference on ICT in Education, Research, and Industrial Applications: Integration, Harmonization, and Knowledge Transfer (ICTERI 2021)*. S. 119–128. Available at: <http://ceur-ws.org/Vol-3104/paper187.pdf> (Accessed on 14.11.2024). [in English].
- Lytvynova, S.H. (2023). Vykorystannia servisu dopovnenoi realnosti Blippbuidery uchyteliamy pryrodnycho-matematychnykh predmetiv v osvithnii praktytsi [Using the Blippbuidery Augmented Reality Service by Teachers of Science and Mathematics Subjects in Educational Practice]. *Naukovyi visnyk Uzhhorodskoho universytetu. Seriya: «Pedagogika. Sotsialna robota»*. № 1 (52). S. 98–106. URL: <https://doi.org/10.24144/2524-0609.2023.52.98-105> (data zvernennia: 14.11.2024) [in Ukrainian].
- Lytvynova, S. H., Burov, O. Yu., Semerikov, S. O. (2020). Kontseptualni pidkhody do vykorystannia zasobiv dopovnenoi realnosti v osvithnomu protsesi [Conceptual Approaches to the Use of Augmented Reality Tools in the Educational Process]. *Suchasni informatsiini tekhnolohii ta innovatsiini metodyky navchannia u pidhotovtsi fakhivtsiv: metodolohiia, teoriia, dosvid, problemy*. № 55. S. 46–62. URL: <https://doi.org/10.31652/2412-1142-2020-55-46-62> (data zvernennia: 14.11.2024) [in Ukrainian].
- Rashevskaya, N. V. (2024). Imersyivni tekhnolohii navchannia pryrodnychykh dystsyplin uchniv starshykh klasiv zakladiv serednoi osvity [Immersive technologies for Teaching Natural Sciences to Students of Senior Classes of Secondary Education Institutions]. *Naukovi zapysky. Seriya: Pedagogichni nauky*. № (213). S. 223–228. URL: <https://doi.org/10.36550/2415-7988-2024-1-213-222-228> (data zvernennia: 14.11.2024) [in Ukrainian].
- Soroko, N. (2024). Osoblyvosti orhanizatsii navchalnykh STEAM-proiektiv iz vykorystanniam imersyivnykh tekhnolohii [Peculiarities of Organizing Educational STEAM Projects Using Immersive Technologies]. *Fizyko-matematychna osvita*. № 2 (39). S. 51–59. URL: <https://doi.org/10.31110/fmo2024.v39i2-07> (data zvernennia: 14.11.2024) [in Ukrainian].
- Lytvynova, S. H., Soroko, N. V., Batsenko, S. V., Bohachkov, Yu. M., Hrybiuk, O. O., Dementiievska, N. P. et al. (2023). Proiektuvannia osvithnoho seredovyschcha z vykorystanniam zasobiv dopovnenoi ta virtualnoi realnosti v zakladakh zahalnoi serednoi osvity [Designing an Educational Environment Using Augmented and Virtual Reality Tools in General Secondary Education Institutions]: kolektyvna monohrafiia. Kyiv: ITsO NAPN Ukrainy. URL: <https://lib.iitta.gov.ua/id/eprint/738596/> (data zvernennia: 14.11.2024) [in Ukrainian].
- Lytvynova, S. H., Soroko, N. V., Bohachkov, Yu. M., Hrybiuk, O. O., Dementiievska, N. P. et al. (2023). Vykorystannia zasobiv dopovnenoi ta virtualnoi realnosti v navchalnomu seredovyschchi zakladiv zahalnoi serednoi osvity [The Use of Augmented and Virtual Reality Tools in the Educational Environment of General Secondary Education Institutions]: metodychni rekomendatsii. Kyiv: ITsO NAPN Ukrainy. URL: <https://lib.iitta.gov.ua/id/eprint/734430/> (data zvernennia: 14.11.2024) [in Ukrainian].
- ISO/IEC TR 23844:2023(en) Information technology for learning, education, and training – Immersive content and technology. (2023). Available at: <https://www.iso.org/obp/ui/en/#iso:std:iso-iec:tr:23844:ed-1:v1:en> (Accessed on 14.11.2024). [in English].

Дата надходження до редакції 15.11.2024 р.

УДК 004.92:37.091.3

DOI: 10.37026/2520-6427-2024-120-4-38-42

Alisa SUKHNIKH,

Candidate of Pedagogical Sciences,
Senior Researcher Institute
of Education Digitalization
of the National Academy
of Educational Sciences of Ukraine,
Kyiv, Ukraine
ORCID: 0000-0001-8186-1715
e-mail: sukhnikh@iitlt.gov.ua

THE POTENTIAL OF VIRTUAL AND AUGMENTED REALITY TO IMPROVE BLENDED LEARNING IN GENERAL SECONDARY EDUCATION

Abstract. Immersive technologies, such as virtual (VR) and augmented (AR) reality, have become one of the most important new tools in education. Their introduction

into blended learning in general secondary education opens up significant opportunities for improving the quality of the educational process, but at the same time poses

a number of challenges for teachers and schools. This article analyzes the impact of immersive technologies on the effectiveness of blended learning, in particular, assessing their impact on student motivation and interaction. The article discusses approaches to the use of virtual and augmented reality in blended learning, methods of integration into the educational process, and describes cases of using immersive technologies to increase the interactivity of the educational environment.

The research results show that immersive technologies contribute to deeper learning, increase student motivation, and create interactive educational environments where each student can freely interact with learning objects, regardless of the physical limitations of the real world. Virtual reality allows for the creation of training simulations that help students practice skills in a safe environment, while augmented reality enriches learning materials with visual elements that promote a better understanding of complex concepts. Particular attention is paid to the impact of these technologies on ensuring active interaction between students and teachers, which is one of the biggest challenges of blended learning.

At the same time, the article discusses the challenges that arise when introducing immersive technologies in

secondary schools. These include the high cost of equipment, technical difficulties associated with setting up and operating VR and AR, and the need to train teachers in new methods of working with these technologies. In addition, the article emphasizes the importance of further research aimed at assessing the long-term impact of immersive technologies on learning outcomes, developing methods for adapting VR and AR to various educational programs, and studying the social and psychological aspects of using immersive environments in education.

In general, the article emphasizes the significant potential of immersive technologies in blended learning, while emphasizing the need for a comprehensive approach for their successful implementation. Investments in equipment, training, and curriculum adaptation are critical to maximizing the effectiveness of these innovations in the educational process. The paper provides recommendations for the optimal use of VR and AR in educational practice to create a more engaging and effective learning environment that promotes both academic and personal development of students.

Key words: immersive technologies, blended learning, general secondary education institutions, educational innovations, virtual and augmented reality.

Аліса СУХІХ,
кандидат педагогічних наук,
старший науковий співробітник
Інституту цифровізації освіти НАПН України,
м. Київ, Україна
ORCID: 0000-0001-8186-1715
e-mail: sukhikh@iitlt.gov.ua

ПОТЕНЦІАЛ ВІРТУАЛЬНОЇ ТА ДОПОВНЕНОЇ РЕАЛЬНОСТІ ДЛЯ ПОКРАЩЕННЯ ЗМІШАНОГО НАВЧАННЯ В ЗАКЛАДАХ ЗАГАЛЬНОЇ СЕРЕДНЬОЇ ОСВІТИ

Анотація. У статті схарактеризовано імерсивні технології, а саме віртуальну (VR), доповнену (AR) та змішану (MR) реальність. Доведено, що вони нині є одним із найважливіших новітніх інструментів у сфері освіти, адже їхнє впровадження у змішане навчання в закладах загальної середньої освіти не лише відкриває значні можливості для підвищення якості освітнього процесу, а й ставить перед учителями та закладами загальної середньої освіти низку викликів.

Проаналізовано вплив імерсивних технологій на ефективність змішаного навчання, зокрема здійснено оцінку їхнього впливу на мотивацію та взаємодію учнів. Окреслено підходи до використання віртуальної та доповненої реальності у змішаному навчанні, методи інтеграції в освітній процес, а також описано кейси використання імерсивних технологій для підвищення інтерактивності освітнього середовища.

На основі наявних результатів досліджень доведено, що імерсивні технології сприяють ґрунтовнішому засвоєнню матеріалу, підвищенню мотивації учнів, створюють інтерактивні освітні середовища,

де кожен учень може вільно взаємодіяти з навчальними об'єктами, незалежно від фізичних обмежень реального світу. Звернено увагу на те, що віртуальна реальність дозволяє створювати навчальні симуляції, що допомагають учням практично відпрацьовувати навички в безпечних умовах, тоді як доповнена реальність збагачує навчальні матеріали візуальними елементами, які сприяють кращому розумінню складних концепцій. Особлива увага приділяється впливу означених технологій на забезпечення активної взаємодії між учнями та викладачами, що є однією з найбільших проблем змішаного навчання.

Обґрунтовано виклики, що виникають у процесі впровадження імерсивних технологій у загальноосвітніх школах, а саме: дороговартісність обладнання, технічні труднощі, пов'язані з налаштуванням та експлуатацією VR та AR, необхідність навчання викладачів новим методикам роботи з цими технологіями. Доведено важливість подальших досліджень, спрямованих на оцінку довгострокового впливу імерсивних технологій на навчальні результати, розробку

методик адаптації VR та AR до різних освітніх програм, а також на дослідження соціальних та психологічних аспектів використання імерсивних середовищ у навчанні.

Закцентовано увагу на значному потенціалі імерсивних технологій у змішаному навчанні, водночас підкреслюючи необхідність комплексного підходу для їх успішного впровадження. Інвестиції в обладнання, підготовку кадрів та адаптацію навчальних програм є критично важливими для забезпечення максимальної ефективності використання цих інновацій в освітньому процесі. Наголошено на оптимальному використанні VR та AR в освітній практиці з метою створення більш захоплюючого та результативного навчального середовища, що сприяє як академічному, так і особистісному розвитку учнів.

Ключові слова: імерсивні технології, змішане навчання, заклади загальної середньої освіти, освітні інновації, віртуальна та доповнена реальність.

Problem statement. The introduction of immersive technologies into blended learning in general secondary education is a complex process associated with numerous challenges that need to be addressed. Virtual reality (VR) and augmented reality (AR) have the potential to dramatically change the approach to learning, creating a more interactive and engaging educational environment. However, their implementation in practice faces a number of challenges.

Immersive technologies such as VR and AR reality require significant resources to implement. The main challenges include the high cost of equipment, technical difficulties in use, and the need to train teachers and students in new technologies. Many general secondary education institutions do not have sufficient funding or technical capabilities to integrate VR and AR into their educational programs.

Despite these challenges, the integration of virtual and augmented reality into the educational process is relevant and necessary for general secondary education institutions. Immersive technologies can make learning more interesting, visual, and personalized. Students can directly interact with the learning material, which contributes to a deeper understanding and assimilation of knowledge. This is especially important for disciplines that require visualization of complex processes or objects, such as chemistry, biology, physics, and others.

One of the main problems with blended learning is the lack of interaction between students and teachers. Due to partial distance learning, students often feel isolated and uninvolved in their work. Immersive technologies can help overcome this problem by creating an environment in which students can actively interact, work in virtual groups, and participate in simulations and experiments.

In online education, it is difficult to ensure high student motivation, especially if the educational process does not provide a sufficient level of interactivity. The lack of personal contact with teachers and other students often leads to a decrease in interest in learning. Immersive technologies can change this situation, as they create a more immersive learning experience that encourages students to be active learners. However, in order to

achieve this effect, it is necessary not only to introduce technologies, but also to provide teachers with appropriate training for their effective use.

In general, the introduction of immersive technologies in blended learning in general secondary education has great potential, but requires overcoming a number of financial, technical, and organizational barriers. It is important not only to provide access to technology, but also to create conditions for its effective use in order to increase student motivation and ensure deep interaction in the learning process.

Analysis of research and publications. Immersive technologies are becoming increasingly popular in the educational environment. Modern research highlights several approaches to their use. The most common is the use of VR to study complex subjects such as anatomy, physics, or chemistry, where interactive simulations allow students to immerse themselves in the material. Augmented reality, in turn, is actively used to improve interaction with educational materials, particularly in science and engineering disciplines. A review of publications shows that both technologies are being actively implemented both in the formal educational environment and for extracurricular activities. The article (Slobodanyk, 2021) analyzes in detail the domestic and foreign experience of using these technologies in the educational process.

World practices of blended learning demonstrate significant success in combining traditional methods with the latest technologies. Studies have shown that combining face-to-face classes with virtual laboratories allows students to consolidate theoretical knowledge in practice, which is particularly effective in the natural sciences. Developed countries are actively implementing VR and AR to create interactive environments that allow students to experiment, collaborate, and explore material in innovative ways (Alam, Hasan, Faiyaz, Bhuiyan, Joy, Islam, 2019; Fitria, 2023; Lee, 2012).

Immersive technologies have become an integral part of educational strategies in these countries, contributing to the individualization of learning and increasing its effectiveness. In a collective monograph (Litvinova, Soroko, Batsenko, ets, 2023), the authors note that VR and AR can be successfully used to individualize learning in Ukrainian schools and to adapt blended learning methods to the needs of modern students, and present models of AR/VR learning environments, classification and principles of their use, pedagogical conditions for implementation, and criteria for evaluating effectiveness and safety.

The purpose of the article. The purpose of this article is to determine the impact of immersive technologies on the effectiveness of blended learning in general secondary education institutions. Particular attention is paid to the study of the possibilities of using virtual and augmented reality to improve the educational process and increase student engagement in the learning process. The article aims to assess both the benefits and challenges associated with the introduction of immersive technologies, in particular in ensuring interactivity, individualizing learning, and increasing student motivation.

In addition, the problems that arise during the implementation of such technologies, including technical, financial and organizational barriers, are considered, and

possible ways to overcome them are suggested. Evaluation of the effectiveness of immersive technologies will allow further development of recommendations for their successful integration into the educational process, which will contribute to creating a more engaging and effective learning environment for students.

Summary of the main research material. The use of virtual reality (VR) in blended learning aims to create conditions for in-depth and interactive learning. One of the main approaches is to use VR for simulations that allow students to interact with objects or environments that are not available in real life. For example, in science courses, students can go on virtual expeditions to places they would not be able to physically visit or conduct experiments that would not be possible in a regular classroom due to safety or financial constraints.

Another approach is to create virtual laboratories where students can experiment, conduct experiments, and learn from their own mistakes in a safe environment. This allows not only to study the material on a theoretical level, but also to gain practical experience that increases understanding of the subject and stimulates interest in learning.

To successfully integrate immersive technologies into the educational process, several methods should be used to maximize student engagement. First, using a blended approach that combines traditional lectures and classes with VR and AR elements allows students not only to receive information but also to actively apply it in practice. It is also important to ensure that teachers are adequately trained to work with immersive technologies, as they are key players in the implementation of such innovations.

Summarizing the results of the teacher survey (Luparenko, Lytvynova, Pinchuk, Sokoliuk, 2022), it can be argued that the pedagogical community of general secondary education institutions demonstrates a high readiness to master augmented and virtual reality technologies. This is due to the urgent need for high-quality digital educational content that simultaneously helps to increase students' motivation to learn and provides effective teaching tools.

Second, it is necessary to introduce training and methodological support for teachers aimed at developing practical skills in working with immersive technologies. Such programs will help teachers integrate VR and AR into the classroom, using them as a means to explain complex concepts and stimulate student interest.

To successfully integrate immersive technologies into the educational process, several methods should be used to maximize student engagement. First, using a blended approach that combines traditional lectures and classes with VR and AR elements allows students not only to receive information but also to actively apply it in practice. It is also important to ensure that teachers are adequately trained to work with immersive technologies, as they are key players in the implementation of such innovations. Another important method is to integrate VR and AR into students' project work. By completing projects using VR or AR, students can create their own virtual models, study historical events or natural phenomena, and present their results in a virtual environment. This encourages students to think critically, be creative, and work collaboratively.

Platforms such as zSpace (<https://zspace.com>), Labster (<https://labster.com>), AR Book (<https://arbook.info>), and Mozaik Education (<https://www.mozaweb.com>) are actively used to integrate VR and AR into the learning process, allowing students to work with virtual models and conduct experiments in a safe environment.

Augmented reality is already being actively used in many schools to increase the interactivity of learning. For example, in biology classes, students can use AR applications to view three-dimensional models of human organs, study their structure and functions. This allows them to better visualize complex anatomical structures and understand the principles of their work. Similar tools are offered by the AR Book platform (<https://arbook.info/>), which allows the creation and use of interactive lessons using AR content, which significantly improves the quality of teaching and student comprehension. Another example is Mozaik Education (<https://ua.mozaweb.com/>), which provides teachers with ready-made AR tools for interactive learning of various disciplines and creating engaging lessons.

Another case study involves the use of AR in geography, where students can view interactive maps, observe changes in terrain, climate, or natural resources in real time. This provides a more visual approach to learning the material and contributes to its better assimilation. Resources such as Nearpod VR (<https://nearpod.com>) help teachers integrate AR into their classes to improve the visualization of learning material.

Immersive technologies also create the conditions for a more personalized approach, where each student can work at his or her own pace, repeat the material or delve into aspects that are particularly interesting to him or her. This makes learning more adaptive and effective, taking into account the individual characteristics of students and contributing to their personal development.

Conclusions. The introduction of immersive technologies in blended learning in general secondary education institutions demonstrates significant potential for improving the educational process. Virtual and augmented reality create opportunities for deeper learning, increased student motivation, and the development of an interactive approach to learning. Students are able to interact with learning materials on a deeper level, which helps improve understanding and retention of information.

At the same time, there are certain challenges associated with the introduction of immersive technologies, including the high cost of equipment, technical difficulties, and the need for teacher training. To successfully integrate VR and AR into the educational process, it is important to address these issues and provide the necessary resources and infrastructure.

In general, immersive technologies have the potential to become an effective tool in the educational process, providing students not only with knowledge but also with important skills such as critical thinking, creativity, and teamwork. The introduction of VR and AR into educational practice can significantly improve the quality of education, but this requires a comprehensive approach that includes investments in equipment, training, and adaptation of educational programs.

Prospects for further research. Further study of

immersive technologies in education requires a detailed analysis of their long-term impact on students' learning outcomes. It is important to investigate how virtual and augmented reality affect the depth of learning, the retention of knowledge in long-term memory, and overall learning success over time. Such research will help us understand the effectiveness of these technologies at different stages of the educational process and help us determine the best strategies for their use.

It is also important to develop methods for adapting immersive technologies to different educational programs. Immersive technologies have great potential for integration into various disciplines, and research should focus on identifying the most effective ways to use VR and AR in each specific subject. This will allow for the creation of adaptive educational programs that take into account the specifics of each discipline and provide the best results for students.

Particular attention should be paid to the use of immersive technologies for students with special education needs. Virtual and augmented reality can greatly improve access to learning for students with physical, sensory, or cognitive difficulties. It can also help learners with learning disabilities better understand abstract concepts through visualization and interactivity. Research should determine which approaches are most effective for different categories of students with disabilities, as well as how to adapt immersive technologies to create an inclusive learning environment.

A separate area for further research concerns the social and psychological aspects of using immersive environments in education. It is important to study how such technologies affect social interaction between students, the development of communication skills, and the emotional state of students. This will help develop tools that ensure not only academic success but also a positive social and psychological experience for each student, creating a more harmonious and supportive learning environment.

REFERENCES

Slobodyanyk, O. V. (2021). Imersevni tekhnolohii u prat-siakh vitchyznianskykh ta zarubizhnykh naukovtsiv [Immersive technologies in the works of domestic and foreign scientists]. *Naukovi zapysky. Seriya «Pedagogichni nauky»*, issue 201, S. 120–124. Available at: <https://doi.org/10.36550/2415-7988-2021-1-201-120-124> (data zvernennia: 05.11.2024). [in Ukrainian].

Alam, M. A., Hasan, M. M., Faiyaz, I. H., Bhuiyan, A., Joy, S. F. A., Islam, S. M. (2019). Augmented Reality Education System in Developing Countries/ *Electronic Imaging*, pp. 183–1–183-11. Available at: <https://doi.org/10.2352/ISSN.2470-1173.2019.2.ERVR-183> (Accessed: 06.11.2024). [in English].

Fitria, T. N. (2023). Augmented Reality (AR) and Virtual Reality (VR) Technology in Education: Media of Teaching and Learning: A Review. *International Journal of Computer and Information System*, 4 (01), pp. 14–25. Available at: https://www.researchgate.net/publication/368655016_Augmented_Reality_AR_and_Virtual_Reality_VR_Technology_in_Education_Media_of_Teaching_and_Learning_A_Review (Accessed: 06.11.2024). [in English].

Lee, K. (2012). Augmented Reality in Education and Training. *TechTrends*, 56 (2), pp. 13–21. Available at: <https://doi.org/10.1007/s11528-012-0559-3> (Accessed: 06.11.2024). [in English].

Lytvynova, S. H., Soroko, N. V., Batsenko, S. V. ta in. (2023). Proiektuvannia osvithnoho seredovysysha z vyko-rystanniam zasobiv dopovnenoj ta virtualnoi realnosti v zakladakh zahalnoi serednoi osvity [Design of the of the educational environment using augmented and virtual reality tools in general secondary education institutions]: kolektyvna monohrafia / za nauk. red. S. H. Lytvynovoi. Kyiv: ITSO NAPN Ukraine. 219 s. [in Ukrainian].

Luparenko, L. A., Lytvynova, S. H., Pinchuk, O. P., Sokoliuk, O. M. (2022). Hotovnist vchyteliv do vyko-rystannia dopovnenoj realnosti v osvithnomu protsesi. *Visnyk Pysliad-yplomnoi Osvity. Seriya «Pedagogichni Nauky»*. Vyp. 21 (50). S. 144–177. Available at: http://umo.edu.ua/images/content/nashi_vydanya/visnyk_PO/21_50_2022/pedagog/Bulletin_21_50_Pedagogika_Luparenko_Lytvynova_Pinchuk_Sokoliuk.pdf (data zvernennia: 11.11.2024). [in Ukrainian].

СПИСОК ВИКОРИСТАНОЇ ЛІТЕРАТУРИ

Слободяник, О. В. (2021). Імерсивні технології у пра-цях вітчизняних та зарубіжних науковців. *Наукові записки. Серія «Педагогічні науки»*. Вип. 201. С. 120–124. URL: <https://doi.org/10.36550/2415-7988-2021-1-201-120-124> (дата звернення: 05.11.2024).

Alam, M. A., Hasan, M. M., Faiyaz, I. H., Bhuiyan, A., Joy, S. F. A., Islam, S. M. (2019). Augmented Reality Education System in Developing Countries. *Electronic Imaging*. Pp. 183–1–183-11. Available at: <https://doi.org/10.2352/ISSN.2470-1173.2019.2.ERVR-183> (accessed: 06.11.2024).

Fitria, T. N. (2023). Augmented Reality (AR) and Virtual Reality (VR) Technology in Education: Media of Teaching and Learning: A Review. *International Journal of Computer and Information System*. 4 (01). Pp. 14–25. Available at: https://www.researchgate.net/publication/368655016_Augmented_Reality_AR_and_Virtual_Reality_VR_Technology_in_Education_Media_of_Teaching_and_Learning_A_Review (accessed: 06.11.2024).

Lee, K. (2012). Augmented Reality in Education and Training. *TechTrends*. Vol. 56 (2). Pp. 13–21. Available at: <https://doi.org/10.1007/s11528-012-0559-3> (accessed: 06.11.2024).

Литвинова, С. Г., Сороко, Н. В., Баценко, С. В. та ін. (2023). Проєктування освітнього середовища з викорис-танням засобів доповненої та віртуальної реальностей в закладах загальної середньої освіти: колективна моно-графія / за наук. ред. С. Г. Литвинової. Київ: ІЦО НАПН України. 219 с.

Лупаренко, Л. А., Литвинова, С. Г., Пінчук, О. П., Со-колюк, О. М. (2022). Готовність вчителів до використання доповненої реальності в освітньому процесі. *Вісник після-дипломної освіти. Серія «Педагогічні науки»*. Вип. 21 (50). С. 144–177. URL: http://umo.edu.ua/images/content/nashi_vydanya/visnyk_PO/21_50_2022/pedagog/Bulletin_21_50_Pedagogika_Luparenko_Lytvynova_Pinchuk_Sokoliuk.pdf (дата звернення: 11.11.2024).

Дата надходження до редакції: 18.11.2024