Immersive cloud-based educational environment of the university: Design principles

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Abstract

This paper presents the principles of designing an immersive cloud-based educational environment for universities. Based on an analysis of the current state and foreign experience in implementing innovative ICT environments in higher education, the key components and design principles of an immersive cloud-based educational environment are identified. These principles include openness and accessibility, personification and adaptability, innovation and practical orientation of technologies, and the integration of traditional and cloud-based learning tools. The paper also discusses the development of teachers' digital competencies necessary for effective work in such an environment. The proposed conceptual provisions form the basis for the systemic design of an immersive cloud-based educational environment as an innovative high-tech educational space focused on the individual development and professionalization of future specialists.

Keywords

immersive learning, cloud technologies, educational environment, design principles, digital competencies

1. Introduction

The development of cloud and immersive technologies opens up new opportunities for modernizing the educational environment of a modern university. The use of cloud-based systems becomes an important condition for increasing the effectiveness of educational interaction and ensuring the personification and adaptability of learning. Immersive technologies, such as virtual and augmented reality, create an effect of presence in an artificial environment and provide the opportunity to interact with virtual objects, which is especially relevant for organizing laboratory work and practical training of students [1].

To provide a comprehensive theoretical foundation for designing immersive cloud-based educational environments, this paper applies the method of theoretical analysis and generalization of scientific

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sources on the problem of designing innovative educational environments. We review and synthesize findings from a diverse range of international studies, including works by Jiang et al. [2], Li and Wong [3], Tene et al. [4], Kong and Feng [5], Sanchez et al. [6], among others. These studies offer valuable insights into the current state and best practices in implementing ICT-enhanced learning environments in higher education contexts across the globe.

The design and implementation of immersive cloud-based educational environments is an urgent task for modern universities. It requires substantiation of theoretical and methodological foundations, determination of the structure and components of the environment, development of methods for using cloud and immersive technologies in educational, scientific and managerial activities. At the same time, it is advisable to rely on both domestic and foreign experience in implementing innovative ICT environments in higher education.

2. Research methods

The study used the following methods:

- theoretical analysis and generalization of scientific sources on the problem of designing innovative educational environments;
- study and analysis of the experience of using cloud and immersive technologies in educational activities of universities;
- systematization and classification of the obtained factual data;
- modeling the structure and principles of designing an immersive cloud-based educational environment.

3. Theoretical foundations

3.1. Analysis of current research on innovative educational environments

A review of recent literature reveals a growing interest in the design and implementation of technology-enhanced educational environments. Jiang et al. [2] conducted a scoping review on the use of virtual reality (VR) in medical students' education. They found that VR has been applied in various medical education contexts, with the majority of studies reporting positive outcomes in terms of knowledge acquisition, skill development, and learner satisfaction. However, they also identified challenges such as cost, technical issues, and the need for more rigorous research designs.

In the context of personalized learning, Li and Wong [3] reviewed the literature on the use of learning analytics. They identified patterns in terms of the environments, stakeholders, objectives, and methods of learning analytics implementation. The review highlighted the growth in the number and diversity of practices, as well as the emergence of teacher-focused perspectives. However, the authors noted that areas such as personalized intervention require further research.

Tene et al. [4] systematically reviewed the integration of immersive technologies, specifically VR and augmented reality (AR), in Science, Technology, Engineering, and Mathematics (STEM) education. They found that AR was the most studied technology, followed by VR, with most studies reporting positive effects on student engagement and performance. The review emphasized the multifaceted benefits of immersive technologies in education but also highlighted the need for a globally inclusive and adaptable framework to keep pace with rapid technological evolution and diverse educational contexts.

Focusing on VR in blended learning, Kong and Feng [5] explored learners' views from a wine classroom. They designed a VR experience system and conducted a mixed-method study to investigate the differences between gaming and instructional VR design. The findings underscored the importance of user interface and user experience considerations, such as replicating real-world sensations, increasing engagement through controllers, providing adequate space for movement, and ensuring comfort. The study suggested that enhancing immersion and realism, customizing the VR experience, and implementing a holistic strategy are critical for improving the efficacy of VR in wine education.

Sanchez et al. [6] compared 45 learning management systems (LMSs) for higher education. They developed an evaluation methodology based on software quality and teaching-learning tools for online educational platforms, considering criteria such as interoperability, accessibility, productivity tools, communication tools, learning tools, and security standards. The study identified Paradiso and Moodle as the best LMSs according to the comparison, with both platforms having a large user base.

These diverse studies highlight the growing adoption and potential of innovative technologies in creating immersive, personalized, and engaging educational environments. However, they also reveal challenges and areas that require further investigation, such as the need for more comprehensive frameworks, rigorous research designs, and consideration of user experiences. The principles and findings from these studies inform our approach to designing an immersive cloud-based educational environment, as detailed in the following sections.

3.2. The ground concept of immersive user environment

According to Bykov [7], an immersive user environment is defined as:

> "An artificially constructed computer-oriented environment of virtual activity, in which special means of computer modeling (scenario-staging and/or computer software and hardware) create a user's sense of quasi-real presence (full or partial) in this environment, and through the use of immersive tools and technologies, their immersion in the virtual world (or mixed real and virtual reality) is achieved, as well as the essence and course of virtual events, providing an additional (compared to non-immersive environments) opportunity to become their observer and/or active participant. If the purpose of building and using an immersive environment is for educational or scientific purposes, then such environments are called immersive environments of educational, training, pedagogical, scientific activity, or their combinations (for example, an immersive environment of educational and scientific activity)." [7]

This definition highlights several key aspects of immersive user environments:

- they are artificially constructed computer-oriented environments that facilitate virtual activities;
- they employ computer modeling techniques to create a sense of quasi-real presence for the user;
- immersive tools and technologies are used to achieve user immersion in the virtual world or mixed reality;
- they provide opportunities for users to become observers and/or active participants in virtual events;
- when designed for educational or scientific purposes, they are referred to as immersive environments of educational, training, pedagogical, or scientific activity.

Bykov's definition emphasizes the role of immersive technologies in creating engaging and interactive virtual environments that can be used for various educational and research purposes. This conceptualization aligns with the principles of designing an immersive cloud-based educational environment discussed in this paper, particularly in terms of leveraging technology to provide learners with rich, interactive experiences and opportunities for active participation.

3.3. The concept and components of an immersive cloud-based educational environment

An immersive cloud-based educational environment (ICBEE) is an innovative technological and pedagogical system that integrates cloud platforms, services, and immersive technologies (such as virtual and augmented reality) with e-learning resources to facilitate interactive and engaging learning experiences [8]. Such an environment ensures the effect of presence, creates conditions for ubiquitous access

to educational services and resources, personification and adaptability of learning, development of professional competencies through the implementation of practice-oriented tasks.

The concept of ICBEE builds upon the principles of cloud computing, immersive learning, and e-learning to create a comprehensive educational ecosystem that supports personalized, adaptive, and experiential learning.

The main components of the ICBEE of the university are [8]:

- cloud-based platforms and services (learning management systems, data warehouses, communication and collaboration tools, analytics tools);
- immersive technologies (virtual and augmented reality systems, 3D modeling, panoramic shooting);
- e-learning resources (multimedia textbooks, video lectures, virtual laboratories, simulators, games);
- methods of using cloud and immersive technologies in the educational process;
- the community of subjects of educational, scientific and managerial activities (teachers, students, scientists, administration).

These components work together to create a flexible, scalable, and interactive learning environment that supports various educational activities, such as online classes, collaborative projects, virtual experiments, and simulations (figure 1).

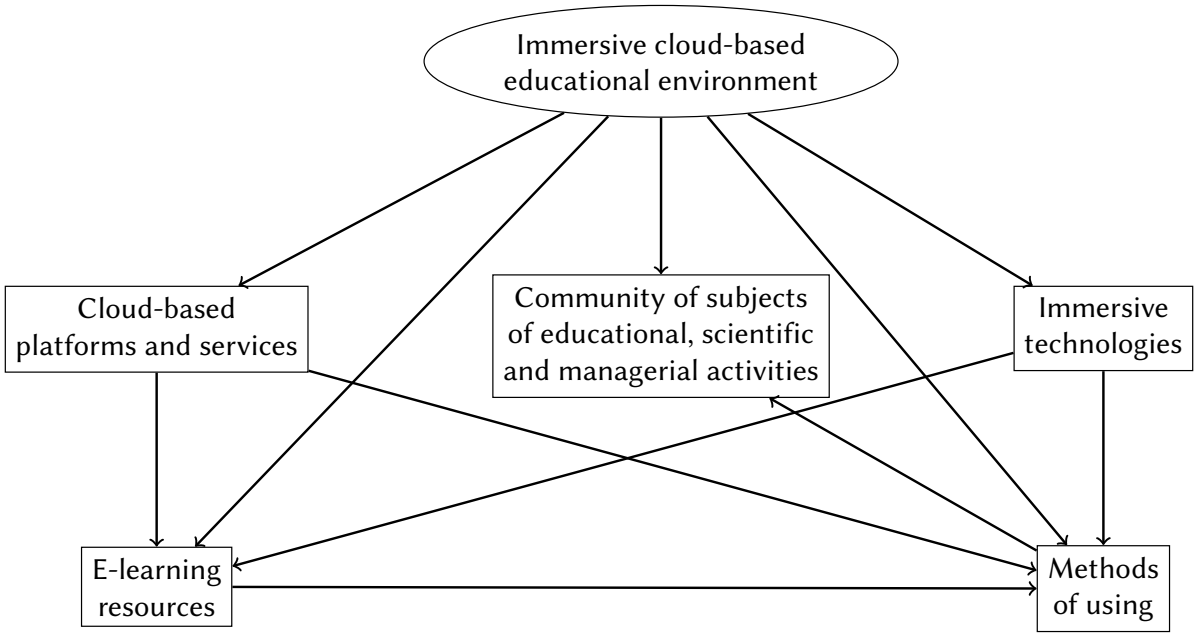

Figure 1: Components of an immersive cloud-based educational environment (ICBEE).

3.4. Experience of using cloud technologies in universities

Ukrainian universities have been actively implementing cloud technologies to support educational, scientific, and managerial activities. At the Kryvyi Rih National University, a cloud-based learning management environment based on the LMS Moodle, integrated with Microsoft Office 365 and Google Apps for Education cloud services, was introduced [9]. This integration allowed for the personalization of students' learning trajectories and the effective monitoring of their academic achievements. The system has been successfully used by over 4,000 students and 300 faculty members, demonstrating its scalability and effectiveness.

Similarly, the Zhytomyr Polytechnic State University has developed an electronic environment that integrates educational, scientific, organizational, and management subsystems using Microsoft cloud

technologies [10]. The environment includes personalized student and teacher portals, which provide access to learning materials, communication tools, and administrative services. The implementation of this environment has led to increased student engagement, improved collaboration between faculty and students, and streamlined administrative processes.

In the context of the COVID-19 pandemic, the use of cloud platforms for organizing distance learning has become relevant, which required the development of recommendations for the selection of cloud services and methods for their use for conducting online classes, monitoring and evaluation, organizing students' independent work under quarantine conditions.

Foreign universities have also made significant strides in adopting cloud technologies. For example, the University of Oxford in the United Kingdom has implemented a cloud-based research data management system using the Figshare platform [11]. This system allows researchers to store, share, and manage their research data securely while complying with data protection regulations. As a result, the university has seen an increase in research productivity and collaboration both within the institution and with external partners.

In the United States, the Massachusetts Institute of Technology (MIT) has partnered with Amazon Web Services to create a cloud-based platform for online learning called MITx [12]. MITx offers a wide range of courses in various disciplines, including computer science, engineering, and business. The platform uses advanced analytics and machine learning to personalize the learning experience for each student, adapting the content and pace to their individual needs. Since its launch in 2012, MITx has attracted over 3.5 million learners from around the world, demonstrating the global reach and impact of cloud-based education.

These examples from Ukrainian and foreign universities showcase the diverse applications and benefits of cloud technologies in higher education, from enhancing learning management systems to supporting research data management and enabling massive open online courses (table 1). As more institutions adopt cloud-based solutions, it is evident that these technologies will play an increasingly crucial role in shaping the future of education.

Table 1
Examples of cloud technology adoption in Ukrainian and foreign universities.

University	Country	Cloud technology adoption
Kryvyi Rih National University	Ukraine	Cloud-based LMS (Moodle) integrated with Microsoft Office 365 and Google Apps for Education
Zhytomyr Polytechnic State University	Ukraine	Electronic environment integrating educational, scientific, organizational, and management subsystems using Microsoft cloud technologies
University of Oxford	United Kingdom	Cloud-based research data management system using Figshare platform
Massachusetts Institute of Technology	United States	MITx: Cloud-based platform for online learning in partnership with Amazon Web Services

3.5. Experience in the design and implementation of immersive educational environments

Foreign universities have significant achievements in the field of designing and implementing immersive educational environments using systems of machine (computer) vision (https://immersiveeducation.org/). Projects on creating inter-university immersive environments are actively implemented. In particular, the Immersive Learning Spaces platform allows students from different universities to collaborate in a single virtual space to carry out joint projects, participate in professional activity simulations, and conduct research. The platform supports a multiplayer mode, has 3D modeling tools, and a built-in communication system.

The world's leading universities consider immersive technologies as an important tool for improving the quality of education, ensuring its practical orientation and compliance with the demands of the digital society. The design of immersive educational environments is carried out based on the integration of various platforms (learning management systems, VR and AR applications, 3D tools, game simulators). At the same time, the principles of personalization, adaptability, gamification of learning, and the development of key competencies through the active activity of students in realistic virtual environments are implemented.

4. The use of cloud technologies and immersive technology tools in the educational, scientific and managerial activities of the university

4.1. Cloud services to support the educational process at the university

Modern cloud platforms offer a wide range of services and tools that can be effectively used to organize and support various aspects of the educational process at the university. First of all, these are learning management systems (LMS) that function according to the SaaS model. The most common cloud LMS are Google Classroom, Moodle Cloud, Canvas, Blackboard Learn, Schoology, etc. These systems allow you to create virtual classes, publish educational materials, organize synchronous and asynchronous communication between learning subjects, monitor and evaluate academic achievements. The use of cloud LMS ensures the implementation of blended and distance learning technologies.

Cloud communication services such as Gmail, Outlook, Exchange Online for corporate email are important for organizing the educational process; Google Meet, Microsoft Teams, Zoom for video conferencing; Viber, Telegram, Skype for instant messaging. These tools allow maintaining constant communication between teachers and students, organizing online classes, consultations, meetings, etc.

Google Apps for Education cloud services and mobile applications (Google Docs, Google Sheets, Google Slides, Google Forms, Google Jamboard, Google Sites) are actively used by teachers to create educational content, organize students' collaboration, design documentation, develop tests and quizzes. Similar features are provided by Microsoft Office 365 tools, in particular Word Online, Excel Online, PowerPoint Online, OneNote, Teams, Forms.

An important aspect is also ensuring the accessibility of the educational environment for people with special needs. Cloud platforms make it possible to integrate assistive technology tools (speech synthesizers, screen magnifiers, touch manipulators), adapt the interface and content to the individual characteristics of users. Immersive technologies, in particular VR, open up unique opportunities for inclusive education, allowing the creation of environments adapted to the capabilities of people with disabilities.

4.2. The use of immersive technologies in the educational and research work of students

Immersive technologies, such as virtual (VR) and augmented (AR) reality, are used to create realistic simulations, virtual laboratories and simulators. They allow reproducing processes and phenomena that are impossible or dangerous to demonstrate in real conditions, to provide interactive interaction with objects of study. The use of VR/AR is especially effective for students to acquire practical skills, in particular when training engineers, medics, and teachers. Immersive technologies increase student engagement, motivation, and level of material assimilation.

Virtual laboratories based on VR technologies allow students to conduct experiments in physics, chemistry, biology, work with unique equipment without the risks and limitations of the real world. In virtual space, students can safely interact with hazardous substances, take accurate measurements, and observe fast-paced processes.

Augmented reality tools can be used to visualize research results and present scientific projects. For example, with the help of AR applications, you can create interactive posters, demonstrate 3D models of developed devices or objects under study, display experimental data. This allows presenting the results in a more visual and understandable form, involving the audience in the active perception of information.

Immersive technologies open up powerful opportunities for students' research work and scientific projects. Thanks to VR systems, students can visit remote research laboratories, unique natural and cultural sites, and interact with leading scientists in telepresence mode. AR technologies allow measuring and analyzing environmental parameters in the field, modeling the impact of various factors on ecosystems, and predicting the development of processes.

The effective use of immersive technologies requires appropriate hardware and software, the development of special content, and the formation of digital competencies of teachers and students.

5. Principles of designing an immersive cloud-based educational environment of the university

The design of an immersive cloud-based educational environment of the university should be carried out on the basis of conceptual provisions and requirements that reflect its specificity as an innovative pedagogical system. The generalization of the experience of implementing cloud and immersive technologies in education, as well as a theoretical analysis of the problem, made it possible to formulate the following basic principles for the design of ICBEE:

1. Openness and accessibility – the architecture of the environment should provide for the possibility of its constant development, adding new functions and services, integrating external resources and tools based on open standards and interfaces.
2. Personification and adaptability – the environment should take into account the individual characteristics, needs and requests of users, provide flexible learning trajectories, adapt content and methods of interaction. This involves collecting and intelligent analysis of user data, building their digital profile.
3. Innovation and practical orientation of technologies – the environment should be designed on the basis of advanced technological and pedagogical solutions, ensure the formation of relevant practical skills and abilities in demand in real professional activities.
4. Integration of traditional and cloud-based learning tools.

Additional principles for the design of ICBEE were identified:

5. Purposefulness and developmental nature – the environment is designed in accordance with the goals of educational activities and should provide conditions for the development of subjects, the formation of their key competencies.
6. Consistency and integrativity – the environment is considered as an integral system that combines various components (technological, informational, pedagogical) based on unified approaches and standards, ensures their functional and content integration.
7. Collaboration and interactivity – the environment should support active communication and cooperation of subjects, provide various forms of synchronous and asynchronous interaction, feedback, joint work on projects and research.
8. Accessibility and inclusiveness – the environment should be accessible for use by different categories of subjects, including those with special needs, provide for adaptive interfaces, assistive technologies, alternative content presentation formats.
9. Security and confidentiality – the design of the environment should take into account the requirements of information security, personal data protection, copyright, prevention of technological risks and failures.

10. Economic efficiency – the choice of platforms, services and tools for building the environment should be based on an assessment of their functionality, scalability and total cost of ownership, the possibility of integration with existing university systems.

The above principles (figure 2) lay the conceptual foundation for the design of the ICBEE of the university as a system that integrates the advantages of cloud and immersive technologies and pedagogical innovations, ensures effective interaction of subjects in a virtual space and the formation of their relevant digital competencies. The application of these principles allows implementing a systematic approach to the design of ICBEE as an innovative high-tech educational environment focused on the individual development and professionalization of future specialists. At the same time, it is important to maintain a balance between technological innovations and the pedagogical expediency of their application, ensuring the psychological comfort and productivity of subjects in the context of the virtualization of the educational process.

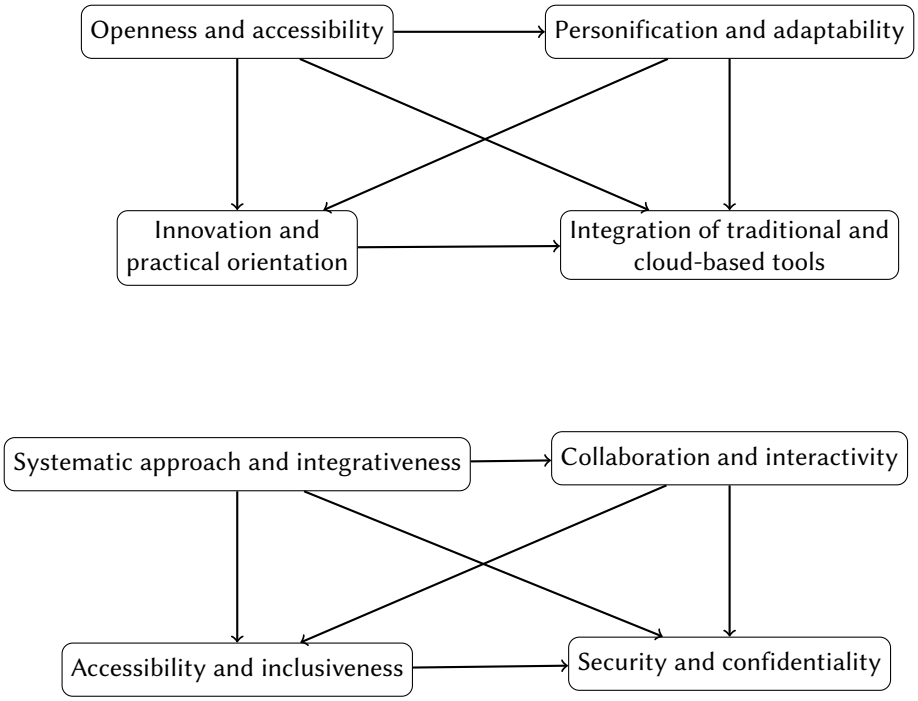

Figure 2: Principles of designing an immersive cloud-based educational environment of the university

The arrows in the diagram show the interconnections between the principles. Thus, the openness and accessibility of the environment create conditions for personification and adaptability of learning, the introduction of innovative practice-oriented technologies, and the integration of traditional and cloud-based tools. A systematic approach to the design of ICBEE involves ensuring the collaboration and interactivity of the environment, its accessibility for various categories of users, and the security and confidentiality of data.

Adhering to these principles when designing an immersive cloud-based educational environment of the university allows for creating an innovative, technologically and pedagogically balanced environment that promotes effective interaction of subjects in the virtual space and the formation of relevant digital competencies.

6. Conclusions

This paper presents a comprehensive analysis of the design and implementation of immersive cloud-based educational environments (ICBEEs) in universities. Through the systematization and classification

of factual data obtained from a review of current research and practices, we identified key trends and challenges in the adoption of cloud and immersive technologies in higher education.

Our analysis revealed that the successful implementation of ICBEEs requires a holistic approach that considers technological, pedagogical, and organizational factors. By modeling the structure of an ICBEE, we identified its core components, including cloud platforms and services, immersive technologies, e-learning resources, methodologies for their integration, and the community of stakeholders involved in the educational process.

Furthermore, we proposed a set of guiding principles for designing effective and engaging ICBEEs:

1. Openness and accessibility.
2. Personification and adaptability.
3. Innovation and practical orientation of technologies.
4. Integration of traditional and cloud-based learning tools.

These principles underscore the importance of creating flexible, user-centered environments that leverage the affordances of cloud and immersive technologies to enhance learning experiences and outcomes.

The application of these principles, along with the consideration of the identified components and best practices, can guide universities in the design and implementation of ICBEEs that are pedagogically sound, technologically robust, and aligned with the needs and expectations of learners and educators in the digital age.

Future research should focus on the empirical evaluation of the effectiveness of ICBEEs in various educational contexts, as well as the development of standardized frameworks and methodologies for their design, implementation, and assessment. By continuing to investigate and refine the principles and practices of ICBEE design, we can harness the potential of these innovative environments to transform and enrich higher education in the 21st century.

References

[1] O. V. Klochko, V. M. Fedorets, Using immersive reality technologies to increase a physical education teacher's health-preserving competency, Educational Technology Quarterly 2022 (2022) 276–306. doi:10.55056/etq.431.

[2] H. Jiang, S. Vimalesvaran, J. K. Wang, K. B. Lim, S. R. Mogali, L. T. Car, Virtual Reality in Medical Students' Education: Scoping Review, JMIR Medical Education 8 (2022) e34860. doi:10.2196/34860.

[3] K. C. Li, B. T.-M. Wong, Personalising Learning with Learning Analytics: A Review of the Literature, in: S. K. S. Cheung, R. Li, K. Phusavat, N. Paoprasert, L. Kwok (Eds.), Blended Learning. Education in a Smart Learning Environment, volume 12218 of *Lecture Notes in Computer Science*, Springer International Publishing, Cham, 2020, pp. 39–48. doi:10.1007/978-3-030-51968-1_4.

[4] T. Tene, J. A. Marcatoma Tixi, M. d. L. Palacios Robalino, M. J. Mendoza Salazar, C. Vacacela Gomez, S. Bellucci, Integrating immersive technologies with STEM education: a systematic review, Frontiers in Education 9 (2024). doi:10.3389/feduc.2024.1410163.

[5] A. Kong, Z. Feng, Advancing VR edutainment design in blended learning: Learners' views from wine classroom, Computers & Education: X Reality 5 (2024) 100078. doi:10.1016/j.cexr.2024.100078.

[6] L. Sanchez, J. Penarreta, X. Soria Poma, Learning management systems for higher education: a brief comparison, Discover Education 3 (2024) 58. doi:10.1007/s44217-024-00143-5.

[7] V. Y. Bykov, Immersive user environment, in: S. H. Lytvynova, N. V. Soroko, O. P. Pinchuk (Eds.), "Immersive technologies in education": a collection of materials of the 2nd Scientific and Practical Conference with International Participation, IDE of NAES of Ukraine, Kyiv, 2022, p. 7. URL: https://lib.iitta.gov.ua/id/eprint/732789/.

[8] S. O. Semerikov, T. A. Vakaliuk, I. S. Mintii, V. A. Hamaniuk, V. N. Soloviev, O. V. Bondarenko, P. P. Nechypurenko, S. V. Shokaliuk, N. V. Moiseienko, D. S. Shepiliev, Immersive e-learning resources: Design methods, in: Digital Humanities Workshop, DHW 2021, Association for Computing Machinery, New York, NY, USA, 2022, p. 37–47. URL: https://doi.org/10.1145/3526242.3526264.

[9] I. Mintii, O. Bondarenko, S. Shokaliuk, K. Polhun, M. Mintii, Analysis of the use of LCMS Moodle in the educational process of KSPU, Educational Dimension 3 (2020) 368–383. doi:10.31812/educdim.v55i0.4366.

[10] A. V. Morozov, T. A. Vakaliuk, The Administration of the Digital Environment of Higher Educational Institutions: the Identification of Users, in: E-learning, STUDIO NOA, 2021, p. 309–322. doi:10.34916/el.2021.13.25.

[11] Research Data Oxford, Figshare, 2024. URL: https://researchdata.ox.ac.uk/figshare.

[12] edX, Massachusetts Institute of Technology, 2024. URL: https://www.edx.org/school/mitx.