

# Information Technologies in the Digital Ecosystem of Higher Education Institutions

Iryna Polishchuk<sup>1</sup>, Yuriy Dovhan<sup>1</sup>, Oksana Yakushevska<sup>1</sup>, Larysa Dovhan<sup>1</sup>,  
Oleksandr Nepochatenko<sup>2</sup> and Viktoriia Petrova<sup>1</sup>

<sup>1</sup>*Vinnitsia Institute of Trade and Economics, State University of Trade and Economics, Soborna Str. 87,  
21050 Vinnitsia, Ukraine*

<sup>2</sup>*Uman National University, Instytutska Str. 1, 20301 Uman, Ukraine*

*i.polishchuk@vtei.edu.ua, y.dovhan@vtei.edu.ua, o.yakushevska@vtei.edu.ua, l.dovhan@vtei.edu.ua,  
nepochatenko2@gmail.com, v.petrova@vtei.edu.ua*

**Keywords:** Information Technologies, Digital Ecosystem, Digital Transformation, Higher Education, Learning Management System, SEL System.

**Abstract:** The article examines the issues of modern information technologies (IT) and their application in higher education institutions. The purpose of the article is to analyze the main areas of application of IT in the digital ecosystem of a higher education institution, covering educational process management, teaching and learning, and scientific research. Comparative, systemic, and structural-functional methods are used to conduct the study. The evolution of IT in education is briefly highlighted from the invention of the printing press to the formation of modern digital ecosystems. The main areas of IT application in higher education institutions are as follows: automation of management and administrative processes; computerization of the educational process; creation of an interactive learning environment; and integration of information and communication technologies into scientific and research activities. Modern IT solutions for each area are described. The practical experience of the Vinnitsia Institute of Trade and Economics of the State University of Trade and Economics is presented as a case study of an integrated digital ecosystem built on its automated management system “Smart Electronic Learning,” and the Moodle educational platform. It is emphasized that the maximum effect of digital transformation is achieved not through the mechanical implementation of individual technologies, but their organic integration into a single digital ecosystem. An integrated approach to implementing IT ensures data integration, eliminates information duplication, and creates a synergistic effect for all participants in the educational process.

## 1 INTRODUCTION

Digital transformation of higher education is one of the key development directions changing traditional educational paradigms, creating new opportunities for managing educational institutions, organizing the educational process, and conducting scientific research. The formation of digital ecosystems in higher education is becoming an essential condition for ensuring the competitiveness of higher education institutions (HEIs), improving the quality of educational services, and enhancing the efficiency of all subsystems' operations. In the context of globalization and rapid technological change, the importance of the comprehensive implementation of IT across all HEI activities is continually growing.

## 2 LITERATURE REVIEW

The international scientific community has actively studied the issue of integrating IT into the educational process over the past decades.

The fundamental aspects of the use of IT in education are considered [1]-[3], aiming to examine the theoretical foundations of the digitalization of the educational space.

The current stage of research is characterized by a transition from general issues to specific aspects of digital transformation. The legal and managerial challenges of the digital era in education have been clarified [4] and the mechanisms of managing educational processes in the conditions of digitalization has been examined [5]. A systematic review of the impact of information and

communication technologies on educational management has been conducted [6] and educational information management systems has been investigated [7].

The processes of implementing educational technologies have been summarized in a systematic review [8], which analyzes the factors of successful adaptation of IT in academic institutions. A comprehensive analysis of the impact of digital technologies on education and aspects of digital transformation has been carried out [9]. The issue of information architecture transformation in the context of university digitalization has been considered [10].

The integration of IT into education and their impact on teaching and learning processes have been investigated [11], [12]. The use of IT in a collaborative approach to education has been considered [13]. The practical challenges of using technologies in classrooms and ways to address them have been analyzed [14], [15].

The dichotomy of hopes and fears regarding IT in education has been investigated [16], and trends in the development of IT in education have been analyzed [17].

Studies on the use of Big Data and AI in education during the COVID-19 pandemic have become particularly relevant [18].

Despite numerous studies on specific aspects of IT applications, the issue of forming an integrated digital ecosystem in HEIs requires further systematic analysis that considers real cases and the practical experience of individual higher education institutions.

### 3 IT EVOLUTION IN EDUCATION

The introduction of IT roots, stemming from humanity's desire to optimize cognitive processes, systematize knowledge, and increase the efficiency of learning through the creation of specialized tools and methods. The evolution of IT in education began long before the emergence of digital computers.

The invention of the printing press by Johannes Gutenberg around 1440 marked the first technological revolution in education. The possibility of mass reproduction of books transformed the educational space when knowledge ceased to be the privilege of a narrow circle and became available to broad segments of the population. This laid the foundation for the development of mass education in subsequent centuries.

At the beginning of the 20<sup>th</sup> century, the first mechanical educational devices appeared. In particular, in the 1920s, S. Pressey developed the testing machine, which allowed students to test their knowledge independently and receive instant feedback. This invention laid the foundation for standardized knowledge assessment and automation of the learning process, foreshadowing the ideas of programmed learning.

In the 1950s-1970s, the era of computer technology in education began. The concept of programmed instruction, developed by B. F. Skinner and J. G. Holland in 1954, demonstrated the possibility of an individualized educational process and the gradual control of the acquisition of knowledge through technical tools.

A revolutionary breakthrough was the emergence of the Programmed Logic for Automatic Teaching Operations system (PLATO) in 1960. It was the first full-fledged interactive computer learning environment that supported multi-user mode, a graphical interface, and elements of social interaction. In parallel, the direction of computer-based learning (Computer-Assisted Instruction, CAI) developed, laying the methodological and technological foundations of modern digital educational systems.

The spread of personal computers in the 1980s enabled the mass implementation of educational software in educational institutions. The creation of computer classrooms and laboratories enabled the integration of traditional teaching methods with interactive simulations, training programs, and automated testing systems, significantly expanding teachers' didactic capabilities.

The emergence of the Internet and the World Wide Web in the early 1990s marked a new stage - the transformation of education into a global, networked space. The first university websites, the use of e-mail in academic communication, and the emergence of learning management systems (LMS). i.e., WebCT (1995) and Blackboard (1997), launched the era of electronic learning (e-learning). These platforms were the first to provide standardized organization of educational content, automated assessment, and systematic interaction between students and teachers in the digital environment.

In the 2000s, a massive introduction of LMS, videoconferencing technologies, electronic libraries, and institutional repositories was observed. These tools provided flexible access to educational resources and interactive participation in the educational process, regardless of participants' geographical location. In addition, integrated

management systems for educational institutions were developed, combining administrative and academic processes in a single digital environment, thereby increasing the efficiency of educational organization and management.

The 2010s were marked by the Massive Open Online Courses movement on platforms such as Coursera, edX, and Udacity, which made high-quality education accessible to millions of people worldwide. Mobile learning, cloud technologies, and the use of social networks as educational tools opened up new forms of communication and collaboration. Education has acquired features of flexibility, personalization, and continuity, supporting various models of distance and self-study.

The current stage of the digital transformation of education, which began in the 2020s, is characterized by the integration of advanced technologies: AI for adaptive learning and personalization of educational trajectories, virtual and augmented reality for creating immersive learning environments, blockchain technologies for verifying and protecting academic documents, and Big Data analytics for predicting success and optimizing educational processes.

The COVID-19 pandemic has become a powerful catalyst for the accelerated digitalization of education, underscoring the crucial importance of educational institutions' technological readiness. This has led to a massive shift toward integrated digital ecosystems that combine LMS, interactive platforms for synchronous and asynchronous interaction, mobile applications, and cloud services. Such convergence of technologies ensures the continuity, flexibility, personalization, and global accessibility of the educational process, forming a qualitatively new model of education in the 21st century.

## **4 KEY DIRECTIONS OF IT APPLICATION IN HIGHER EDUCATION**

The higher education system includes various institutions, from governance and quality assurance bodies to research institutions, coordination bodies, library consortia, as well as information and analytical centers. At the same time, higher education institutions are the primary drivers of educational, scientific, and innovative activities, and their digital transformation determines the level of technological development across the entire system. HEI's digital ecosystem is a complex multi-level system of

interconnected technological solutions that provide information support for all aspects of the university's operation. The functional structure of IT applications in HEIs is universal, determined by their typical tasks, regardless of organizational and legal form, profile, or scale. The concept of a digital ecosystem involves not only the implementation of individual IT solutions, but also systemic integration, which creates a synergistic effect and qualitatively new opportunities for the development of educational, scientific, and managerial activities.

Analysis of general patterns of IT application in higher education enables us to identify typical areas of digitalization.

HEIs' activities are traditionally structured into three main areas: the management of the academic process, teaching and learning, and scientific research. Accordingly, digital transformation encompasses implementing IT across the following areas: automating management and administrative processes, computerizing the educational process and creating an interactive academic environment, and integrating IT into scientific and research activities.

### **4.1 IT in the Educational Process Management**

The main goal of implementing IT in management activities is to increase the efficiency of administrative processes, ensure transparent decision-making based on objective data, optimize resource use, and create a single information space for the institution.

The use of IT in management is defined by the need to integrate heterogeneous organizational processes, ensure differentiated access to information for different user categories, guarantee the security of personal data in accordance with the law, and provide comprehensive analytical reporting to support management decisions.

Currently, comprehensive corporate management information systems tailored for the educational sector are being introduced. They include Campus Management, Ellucian Banner, Oracle PeopleSoft Campus Solutions, etc. These systems integrate the functions of managing the student contingent, human resources, finance, the material and technical base, as well as scientific activities on a single platform. Electronic document management systems (M.E.Doc, ASKOD EDMS, DocuSign, etc.) automate administrative procedures, enable electronic approval, and support document digital signatures. Data analytics systems enable multidimensional analysis of educational data, the creation of interactive management dashboards, the

prediction of performance indicators (e.g., the risk of student expulsion and the demand for educational programs), and the identification of problem areas.

Electronic Dean's offices automate the accounting of academic performance, the creation of individual curricula, and the issuance of academic certificates and diploma documents. Student relationship management systems optimize the processes of the admission campaign and communication with potential students. Promising areas of development of managerial IT include the implementation of AI for predictive analytics and automation of routine administrative processes, the use of blockchain technologies to verify academic documents and ensure their international recognition, the development of mobile applications for quick access to management information, integration with national educational information systems, and global data exchange platforms, as well as the implementation of systems for automatic monitoring of the quality of educational services based on Big Data analysis.

## 4.2 IT in Teaching and Learning

The purpose of implementing IT in the educational process is to improve the quality of educational services by ensuring interactive learning, personalizing educational trajectories, expanding access to high-quality academic resources, and developing students' digital competencies.

The use of educational technologies requires their pedagogical adaptation to the specifics of academic courses, user-friendly interfaces for different user groups, multimodal forms of learning (synchronous, asynchronous, blended), and integration with systems for assessing academic performance. The modern technological infrastructure of the academic process is based on the integration of various digital tools. LMS (Moodle, Canvas, Blackboard, Google Classroom, etc.) provide structured placement of educational content, interactive elements (forums, wikis, glossaries), automated testing, tracking student progress and reporting, and communication among participants in the educational process.

Video conferencing platforms (Zoom, Microsoft Teams, Google Meet, BigBlueButton, etc.) provide synchronous remote interaction, including document collaboration, screen sharing, and breakout rooms.

Adaptive AI-based learning systems (Knewton, Smart Sparrow, Century Tech, etc.) manage personal development planning according to individual needs, learning pace, and students' information perception.

Virtual and augmented reality (VR/AR) technologies create immersive learning environments

for practical training in medicine, engineering, and architecture.

Academic integrity control systems (such as Turnitin, Unicheck, StrikePlagiarism, etc.) ensure the originality of student work.

Electronic library systems provide access to digital educational resources, scientific databases, and electronic textbooks. Interactive content creation tools (H5P, Articulate, Adobe Captivate, etc.) allow teachers to develop multimedia learning materials.

Electronic assessment systems (Gradescope, Crowdmark, ZipGrade, ExamSoft, etc.) and LMS assessment modules automate testing and grading.

The prospects for the development of educational technologies are associated with the deepening of personalization of learning through the use of AI and machine learning to analyze individual academic needs, the expansion of using VR/AR to create realistic simulations of complex processes and phenomena, the introduction of gamification technologies and serious games to increase student motivation, the development of microlearning and adaptive mobile applications for learning at any time and place, the use of AI-based chatbots for 24/7 student support, the integration of Learning Analytics technologies for in-depth analysis of understanding behavior and prediction of success, as well as the development of social learning through the integration of educational platforms with social networks.

## 4.3 IT in Scientific Research

The use of IT in scientific activities aims to intensify research processes, ensure the openness and accessibility of scientific results, increase the visibility of the institution's publication activity in the international scientific space, and build an infrastructure for international scientific cooperation.

It is specified by the need to ensure long-term storage of research data, support international academic metadata standards, integrate with global scientific databases, and adhere to the principles of Open Science.

The modern infrastructure of digital scientific activities includes various technological components.

Institutional repositories (based on DSpace, EPrints, Fedora, etc.) provide long-term storage and open access to scientific publications, dissertations, research reports, and conference proceedings in accordance with the principles of Open Access.

Current research information systems (PURE, Converis, VIVO, etc.), integrate data on research projects, publications, patents, scientific events, and grants, and allow researchers to be profiled.

Bibliometric platforms (Scopus, Web of Science, Google Scholar, etc.) provide analysis of scientific impact through citation indices (h-index, impact factor), the detection of scientific connections, and the analysis of cooperation networks.

Data visualization and analysis tools (Tableau, Power BI, RStudio, Python libraries, etc.) enable the processing of large amounts of research data and the presentation of results in visual form.

Plagiarism-detection systems for scientific texts (iThenticate, CrossCheck, etc.) ensure the originality of research and academic integrity.

Collaborative research platforms (ResearchGate, Academia.edu, Mendeley, etc.) facilitate academic communication, the exchange of scientific results, and the formation of research networks.

Bibliography management systems (Zotero, EndNote, Mendeley, etc.) automate work with scientific sources and the formation of references.

Cloud platforms for scientific computing (Google Colab, Amazon Web Services, Microsoft Azure, etc.) provide power for resource-intensive computing.

Promising directions for the development of scientific IT include the introduction of AI for automated analysis of scientific literature, trend identification and hypothesis generation, expanding the use of semantic technologies and linked data for the integration of scientific knowledge, development of FAIR data infrastructure to ensure the repeatability of research, implementation of blockchain technologies for intellectual property protection and authorship verification, creation of Virtual Research Environments for international scientific cooperation, integration with global scientific infrastructures (ORCID, Crossref, DataCite, etc.), development of open peer review systems, as well as the use of digital twins technologies for modeling complex scientific systems.

Analysis of the current state of IT applications in HEIs reveals a wide range of solutions tailored to each functional area of the university's activities. At the same time, a maximum effect of digital transformation is achieved not through the mechanical accumulation of individual technologies, but through their organic integration into a single digital ecosystem. Such integration ensures data connectivity, eliminates information duplication, optimizes organizational processes, and creates qualitatively new opportunities for the institution's development. The practical implementation of the concept of an integrated digital ecosystem requires a systematic approach and strategic planning, as evidenced by the experience of particular educational institutions.

## 5 INTEGRATED DIGITAL ECOSYSTEM: VITE SUTE EXPERIENCE

The formation of the digital ecosystem is represented based on the practical experience of the Vinnytsia Institute of Trade and Economics of the State University of Trade and Economics (VITE SUTE). The Institute's integrated digital ecosystem is built on two key platforms: its own automated educational process management system ("Smart Electronic Learning", SEL), and the open-source LMS Moodle. Being interconnected, these systems provide comprehensive information support for the Institute's management, educational, and scientific activities.

The SEL development began in 2020 to create a tool aligned with the Institute's existing operational processes and the specifics of higher education in Ukraine. The system was developed in accordance with state standards governing the creation of automated systems. This approach is substantiated by the fact that most automated management systems on the Ukrainian IT market do not provide a complete cycle of automation for educational processes [19].

A modern web technology stack was used in the development of SEL, ensuring scalability, performance, and ease of maintenance. The backend is implemented using the PHP programming language (versions 7.4/8.0) with the Yii2 framework (version 2.0.13+), which supports MVC architecture and a component-based approach to application development. MySQL 8.0 is used for data storage, guaranteeing reliability through transaction support and ACID properties. The client-side of the system is built using the AdminLTE 3.0 template, which is based on the Bootstrap 4 framework. The jQuery library is used to implement dynamic user interaction. The system's deployment infrastructure is built using Docker containerization and Docker Compose for service orchestration, along with an Nginx (Alpine) web server acting as a reverse proxy and PHP-FPM for handling server-side requests.

The system architecture is built on a modular principle and comprises five main components. The "Teaching" module integrates E-Register, the Lecturer's Individual Work Plan, and the Individual Repository. The "Student" module provides an electronic gradebook, a grade register, and an elective course selection system. The "Services" module combines the functions of the Dean's office, the Human Resources Department, workload distribution, and timetable generation. The "Repository" module provides storage and access to electronic publications of the teaching staff. The

“Internal Resources” module integrates document flow and connects to the Moodle platform.

The “Lecturer’s Individual Work Plan” module is an tool for planning, monitoring, and evaluating the professional activities of staff. The module integrates all types of work of the academic staff. The system automatically imports data on teaching workload distribution, generates reports on plan implementation for a selected period, and provides real-time monitoring of task completion. Integration of this module with other system components (timetable, workload, and research publications) ensures control over the lecturer’s activities.

The “Timetable” module operates on the basis of a personalized teaching workload database and provides the creation and maintenance of an electronic register of the lecturer’s workload. The system automatically registers additional classes, tracks class substitutions, and generates schedules for lecturers and academic groups.

A unique SEL module is the automated system for elective course selection, which enables students to plan their personal development. The system allows learners to access elective course information via the attached syllabi, select the course they are interested in, and automatically subscribe to it. All processes, including registration, data processing, and analysis, are automated by the system, significantly reducing the time and labor costs for administrative staff.

To maintain the academic process, VITE SUTE uses the Moodle platform, a learning environment widely used as one of the most commonly used open-source LMS platforms. Moodle hosts teaching materials for each particular course and provides interactive tools, student activity tracking, and an electronic gradebook.

Integration between Moodle and the SEL is carried out through the “Internal Resources” module. It connects the Institute’s management infrastructure and the learning space. It ensures an ongoing information flow: data on students, their enrollment, and curricula are generated in SEL and made available on the Moodle platform without duplication. Moodle acts as a platform for hosting educational materials, while SEL functions as an performance monitoring system, with data exchange via API and single sign-on support.

The SEL also supports the representation of the teaching staff’s scientific activity through several key modules. The Institutional repository is integrated into the system through the “Repository” module and provides long-term storage and open access to electronic publications of the teaching staff. After checking student work for originality, the system automatically places it in the teacher’s repository, optimizing the scientific archiving process.

The “Plagiarism” module verifies the originality of students’ Master’s research projects by comparing them with a database of research papers submitted in previous years.

The construction of the digital ecosystem of the VITE SUTE, based on the integration of the SEL and Moodle, demonstrates the practical implementation of the concept of an integrated digital ecosystem for HEIs. The module architecture of the SEL enables integration with other Institute tools and systems, as well as scalability to meet the needs of different user categories.

Integration of systems ensures several key outcomes. First, a single information space is formed in which all participants of the educational process, including students, teachers, and administrative staff, work with up-to-date data in real time. Second, duplication of information is eliminated, so that data on students, curricula, and assessment results are entered once and automatically distributed between related modules. Third, a comprehensive analysis of the Institute’s activities, from planning the educational process to monitoring teachers’ scientific activities, is provided.

Thus, the experience of VITE SUTE confirms that a comprehensive, integrated approach to implementing IT is an effective tool for the digital transformation of a higher education institution, ensuring increased efficiency in management, educational, and scientific processes.

## 6 CONCLUSIONS

The analysis of the current state of IT applications in higher education shows that digital transformation covers all the main areas of HEI activity: educational process management, teaching and learning, and scientific research. The evolution of educational technologies from simple learning machines to integrated digital ecosystems indicates a constant growth of their role in ensuring the efficiency and high quality of education. The analysis of a wide range of modern IT solutions - from educational institution management systems and LMS to bibliometric systems and data analysis tools - reveals a robust technological infrastructure capable of meeting the needs of modern universities.

The experience of VITE SUTE confirms that the maximum effect of digital transformation is achieved not through the mechanical implementation of individual technologies, but their organic integration into a single digital ecosystem. The developed integrated system, combining its SEL with the Moodle, ensures data integration, eliminates

information duplication, and creates a synergistic effect for all participants in the educational process. The results of the study can serve as a basis for further development in the field of forming integrated digital ecosystems of HEIs, in particular for developing methodological principles for planning and implementing IT strategies.

## REFERENCES

- [1] H. Amca, "Information Technology in Education," in *School of Computing and Technology*, Eastern Mediterranean University, pp. 1-4, Mar. 2001.
- [2] W. R. Muir, "Information Technology and Education," in *Quality of Human Resources: Education*, Encyclopedia of Life Support Systems, vol. 3, UK: EOLSS Publishers, 2009.
- [3] F. Hamidi, M. Meshkat, M. Rezaee, and M. Jafari, "Information Technology in Education," in *Procedia Computer Science*, vol. 3, pp. 369-373, 2011, [Online]. Available: <https://doi.org/10.1016/j.procs.2010.12.062>.
- [4] Z. Li and W. Zhang, "Technology in education: Addressing legal and governance challenges in the digital era," in *Education and Information Technologies*, vol. 30, pp. 8413-8443, 2025, [Online]. Available: <https://doi.org/10.1007/s10639-024-13036-9>.
- [5] L. Rahm, "Educational imaginaries: Governance at the intersection of technology and education," in *Journal of Education Policy*, vol. 38, no. 1, pp. 46-68, 2023, [Online]. Available: <https://doi.org/10.1080/02680939.2021.1970233>.
- [6] T. Liu, Y. T. Luo, P. C.-I. Pang, and H. Y. Kan, "Exploring the impact of information and communication technology on educational administration: A systematic scoping review," in *Education Sciences*, vol. 15, no. 9, p. 1114, 2025, [Online]. Available: <https://doi.org/10.3390/educsci15091114>.
- [7] S. D. Kurniasih, "Information and communication technology in educational management information system," in *Indonesian Journal of Islamic Communication*, vol. 6, no. 1, pp. 125-138, 2023, [Online]. Available: <https://doi.org/10.35719/ijic.v6i1.2212>.
- [8] A. Granić, "Educational technology adoption: A systematic review," in *Education and Information Technologies*, vol. 27, no. 7, pp. 9725-9744, 2022, [Online]. Available: <https://doi.org/10.1007/s10639-022-10951-7>.
- [9] S. Timotheou, O. Miliou, Y. Dimitriadis, S. Villagrà Sobrino, N. Giannoutsou, R. Cachia, A. Martínez Monés, and A. Ioannou, "Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review," in *Education and Information Technologies*, vol. 28, pp. 6695-6726, 2023, [Online]. Available: <https://doi.org/10.1007/s10639-022-11431-8>.
- [10] N. Bobro, "Transforming information architecture in the context of university digitalization," in *Information Technologies in Education*, no. 1 (57), pp. 7-13, 2025, [Online]. Available: <https://doi.org/10.14308/ite000788>.
- [11] D. Mdhlalose and G. Mlambo, "Integration of technology in education and its impact on learning and teaching," in *Asian Journal of Education and Social Studies*, vol. 47, no. 2, pp. 54-63, 2023, [Online]. Available: <https://doi.org/10.9734/ajess/2023/v47i21021>.
- [12] F. Duraku, "Information technology in teaching and learning in education," in *E-Journal VFU*, vol. 23, pp. 244-258, 2025, [Online]. Available: <https://doi.org/10.53606/evfu.23.244-258>.
- [13] N. Zamkova, I. Polishchuk, Yu. Dovhan, L. Dovhan, and R. Novytskyi, "Training of future logistics and supply chain managers: A competency approach," in *Financial and Credit Activity: Problems of Theory and Practice*, vol. 1, no. 48, pp. 427-440, 2023, [Online]. Available: <https://doi.org/10.55643/fcaptop.1.48.2023.3946>.
- [14] A. M. Johnson, M. E. Jacovina, D. E. Russell, and C. M. Soto, "Challenges and solutions when using technologies in the classroom," in *Adaptive Educational Technologies for Literacy Instruction*, pp. 13-29, 2016, [Online]. Available: <https://doi.org/10.4324/9781315647500-2>.
- [15] M. Liu, R. Zhou, J. Dai, and X. Feng, "Analysis and practice of using modern information technology for classroom teaching mode reform," in *Mobile Information Systems*, vol. 2022, 2022, [Online]. Available: <https://onlinelibrary.wiley.com/doi/epdf/10.1155/2022/2565735>, [Accessed: 25 Jan. 2026].
- [16] J. Łaszczczyk, "Information technology in education - hopes and fears," in *International Journal of Electronics and Telecommunications*, vol. 61, no. 3, pp. 261-266, 2015, [Online]. Available: <https://doi.org/10.1515/eletel-2015-0034>.
- [17] D. Hawkrigde, *New Information Technology in Education*, 1st ed., London, UK: Routledge, 2022, [Online]. Available: <https://doi.org/10.4324/9781003312826>.
- [18] J. Zhao and Q. Li, "Big data-artificial intelligence fusion technology in education in the context of the new crown epidemic," in *Big Data*, vol. 10, no. 3, pp. 262-276, 2022, [Online]. Available: <https://doi.org/10.1089/big.2021.0245>.
- [19] L. M. Radzikhovska, O. V. Ivashchuk, R. M. Novytskyi, V. V. Romanuke, and S. A. Yaremko, "The automated system 'SEL' as a tool for higher education institution management," in *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, vol. 2025, no. 3, pp. 212-220, 2025, [Online]. Available: <https://doi.org/10.33271/nvngu/2025-3/212>.