



ІНФОРМАЦІЙНО-КОМУНІКАЦІЙНІ ТЕХНОЛОГІЇ В ОСВІТІ

УДК 378.018.43:004:60-051

DOI <https://doi.org/10.5281/zenodo.20519642>

Digital technologies as a tool for implementing an integrated approach to the professional training of master's students in biotechnology under blended learning conditions

Olena Kuznetsova,

Candidate of Biological Sciences, Associate professor, Department of Medicinal Chemistry and Toxicology, Bogomolets National Medical University,
13, T. Shevchenko blvd, Kyiv, 01601, Ukraine
<https://orcid.org/0000-0002-5229-0287>

Violetta Narokha,

Candidate of Pharmaceutical Sciences, Associate professor, Department of Medicinal Chemistry and Toxicology, Bogomolets National Medical University,
13, T. Shevchenko blvd, Kyiv, 01601, Ukraine
<https://orcid.org/0000-0001-7676-0223>

Accepted: 14.05.2026 | Published: 30.05.2026

Abstract. *The article considers the application of digital technologies as an effective tool for facilitating knowledge transfer within an integrated approach to teaching a professional discipline. The aim of the study was to conduct a theoretical analysis of the effectiveness of digital technologies as a tool for implementing an integrated approach to the professional training of master's students in biotechnology in a blended learning environment, using the discipline "Modern Methods of Research of Biological Objects" as a case study. Methods.* *The study was*



conducted at the Department of Medicinal Chemistry and Toxicology at Bogomolets National Medical University. The methodological basis of the study was an integrated approach to teaching implemented using digital technologies. The educational process was organized in a blended learning format, combining traditional classroom instruction with a distance learning component. The LikarNMU educational platform was used to provide digital support for learning, offering access to teaching materials, interactive tasks, educational resources, communication tools, and assessment instruments. **Results.** The essence of the integrated approach is theoretically substantiated, and its role in the formation of professional competencies among higher education students is defined. In this context, the tools for information exchange across various components of the discipline are described, including educational platforms, data visualization tools, and communication technologies within a blended learning environment. The didactic potential of digital tools, particularly virtual laboratories and cloud-based services, is examined. It is emphasized that these tools primarily support asynchronous communication, which is conditioned (better replaced) by their reliance on client–server architecture as a fundamental principle of the global network infrastructure. The study demonstrates that the integration of the integrated approach with blended learning facilitates the development of a holistic system of professional competencies required for careers in biotechnology, biomedicine, and pharmacy, while also enhancing graduates' competitiveness in the modern labor market. The implementation of this approach necessitates the transformation of traditional pedagogical practices, the modernization of didactic models, the digitalization of educational and methodological support, and the adoption of tools for automating educational processes. **Conclusions.** Further development of the integrated approach is associated with the implementation of artificial intelligence technologies, the use of adaptive learning platforms, and the creation of interdisciplinary digital educational environments. At the same time, it is emphasized



that, alongside the advantages of asynchronous forms of interaction, synchronous methods of knowledge transfer remain highly relevant and are evolving within the digital environment.

Keywords: *IT technologies, distance learning, biotechnology education.*

Цифрові технології як інструмент реалізації інтегрованого підходу до професійної підготовки магістрів біотехнології в умовах змішаного навчання

Олена Кузнецова,

Кандидатка біологічних наук,
доцентка кафедра хімії ліків та лікарської токсикології,
Національний медичний університет ім. О.О.Богомольця,
Б-р Т.Шевченка, 13, Київ, 01601, Україна
<https://orcid.org/0000-0002-5229-0287>

Віолетта Нароха,

Кандидатка фармацевтичних наук,
доцентка кафедри хімії ліків та лікарської токсикології,
Національний медичний університет ім. О.О.Богомольця,
Б-р Т.Шевченка, 13, Київ, 01601, Україна
<https://orcid.org/0000-0001-7676-0223>

Анотація: *У статті розглядається модель використання цифрових технологій як ефективний інструмент передачі знань у контексті інтегрованого підходу у викладанні дисципліни професійного спрямування. Мета дослідження - теоретично проаналізувати ефективність використання цифрових технологій як інструменту реалізації інтегрованого підходу у*



професійній підготовці магістрів-біотехнологів в умовах змішаного навчання (на прикладі викладання дисципліни «Сучасні методи дослідження біологічних об'єктів»). **Методи.** Дослідження проводилося на кафедрі хімії ліків та лікарської токсикології Національного медичного університету ім. О.О.Богомольця. Методологічною основою дослідження став інтегрований підхід до викладання, реалізований за допомогою цифрових технологій. Навчальний процес був організований у форматі змішаного навчання, що поєднував традиційне аудиторне навчання з дистанційним компонентом. Для цифрової підтримки навчання використовувалася освітня платформа *LikarNMU*, яка забезпечує доступ до навчально-методичних матеріалів, інтерактивних завдань, інтерактивних освітніх ресурсів, комунікаційних інструментів та засобів оцінювання результатів навчання. **Результати.** Теоретично обґрунтовано сутність інтегрованого підходу та визначено його роль у формуванні професійних компетентностей здобувачів вищої освіти. В цьому контексті описано засоби обміну інформацією для різних компонентів вивчення дисципліни, зокрема освітні платформи, засоби візуалізації даних, засоби комунікації тощо, за умов змішаної форми навчання. Проаналізовано дидактичний потенціал цифрових інструментів, зокрема віртуальних лабораторій та хмарних сервісів. Підкреслюється, що ці інструменти переважно реалізують асинхронну комунікацію, що зумовлено використанням клієнт-серверної архітектури як базового принципу функціонування глобальної системи взаємопов'язаних мереж. Показано, що поєднання інтегрованого підходу зі змішаним навчанням забезпечує формування цілісної системи професійних компетентностей, необхідних для діяльності у сфері біотехнології, біомедицини та фармацевтики, а також підвищує конкурентоспроможність випускників на сучасному ринку праці. Імплементация зазначеного підходу зумовлює необхідність трансформації традиційних педагогічних практик, модернізації дидактичних моделей,



цифровізації навчально-методичного забезпечення, а також впровадження інструментів автоматизації освітніх процесів. **Висновки.** Подальше вдосконалення інтегрованого підходу пов'язане із впровадженням технологій штучного інтелекту, використанням адаптивних освітніх платформ та розбудовою міждисциплінарних цифрових освітніх середовищ. Водночас наголошується, що поряд із перевагами асинхронних форм взаємодії зберігається актуальність синхронних способів передачі знань, які набувають нових форм у цифровому середовищі.

Ключові слова: ІТ-технології, дистанційне навчання, біотехнологічна освіта

Introduction. Modern higher education is undergoing structural transformations driven by the development of information and communication technologies and their integration into the educational environment. One of the key directions in the modernization of the educational process is the implementation of blended learning, which combines traditional pedagogical approaches with the use of digital educational platforms, learning management systems, remote interaction tools, and learning analytics instruments. This learning model contributes to increased flexibility and adaptability of the educational process, enhances its practical orientation and alignment with contemporary educational standards, and promotes the development of students' digital and professional competencies, thereby increasing their competitiveness in the modern labor market [1, 2].

Contemporary military events in Ukraine and worldwide, epidemics, and other modern challenges are shaping new requirements for the organization of the educational process, particularly the need to ensure its continuity through digital technologies. Under these conditions, blended learning is regarded as a fundamental model for organizing the educational environment, as it enables asynchronous access



to educational resources, supports synchronous interaction, and facilitates the integration of communication and collaborative tools. Within blended learning, an integrated approach is a key factor that ensures a balance between academic rigor and the flexibility of the educational process [3, 4]

Literature review. Educational transformations resulting from the digitalization of society and the rapid advancement of scientific and technological industries, particularly biotechnology, underscore the need to update the content, forms, and methods of training future specialists. In the context of the digitalization of education, the integrated approach is gaining particular importance, as it involves combining fundamental theoretical knowledge with practical skills, as well as fostering interdisciplinary integration through the use of modern IT solutions [5-7]. Digital technologies serve as a key instrument for implementing an integrated approach to training master's-level specialists in biotechnology, facilitating the integration of fundamental biological knowledge, engineering skills, and modern information tools (bioinformatics and AI). In particular, the use of virtual laboratories, simulation environments, cloud-based services, and intelligent learning support systems enhances the effectiveness of mastering complex scientific concepts and contributes to the development of students' research and analytical skills [8, 9]. The implementation of such an approach not only improves the efficiency of learning outcomes but also facilitates the formation of an integrated system of professional competencies that corresponds to the current requirements of higher education.

The rapid development of biotechnology requires specialists not only to possess solid theoretical knowledge but also to be able to select appropriate methods for the analysis, isolation, and purification of biological agents, operate modern laboratory equipment, and implement the latest scientific advances in practice. Competencies in molecular biology, genetics, cell technologies, and bioinformatics are also essential, as they enable the integration of knowledge and skills needed to solve complex scientific and applied problems in pharmaceutical, medical, and



industrial biotechnology [10-13]. In this context, the course "Modern Methods for the Study of Biological Objects" (MMSBO) plays a key role in the development of professional competencies in master's students in biotechnology. The course involves mastering advanced methods, analytical tools, and laboratory practices, thereby fostering critical thinking, practical skills, and readiness to apply scientific advances in high-tech industries.

Identification of previously unresolved aspects of the general problem. The relevance of the study is determined by the need to identify effective ways of implementing an integrated approach to teaching biochemistry within the context of blended learning framework, particularly in the course "MMSBO" for master's-level students in the specialty G21 "Biotechnology and Bioengineering" within the field of knowledge G "Engineering, Production, and Construction" and the development of professional competencies of master's-level biotechnologists in this course.

Purpose of the article (problem statement).

The purpose of the study is to theoretically substantiate and analyze the effectiveness of using digital technologies as a tool for implementing an integrated approach in the professional training of master's-level biotechnologists within blended learning, using the example of teaching the course "MMSBO"

Formulation of the objectives of the article (research tasks):

1. to theoretically substantiate the essence of the integrated approach and determine the role of digital technologies in its implementation within blended learning;
2. to analyze the capabilities and didactic potential of digital technologies in the professional training of master's-level biotechnologists;
3. to characterize a model for the use of digital tools in teaching the course "MMSBO";
4. to identify prospects for improving the integrated approach based on the digitalization of the educational process.



The study was conducted at the Department of Medicinal Chemistry and Toxicology of Bogomolets National Medical University. The methodological basis of the study was the integrated approach to teaching the course “MMSBO, implemented through the use of digital technologies. The educational process was organized in a blended learning format that combined traditional classroom instruction with a distance learning component. For digital support of learning, the educational platform LikarNMU was used, providing access to teaching and methodological materials, interactive assignments, interactive educational resources, communication tools, and means of assessing learning outcomes. [14] The study employed the Action Research methodology (practice-oriented research) [15].

Results of the study.

This study, within the framework of blended learning, considers the integrated approach as a system-forming component of the digital educational environment that ensures the congruence of educational content, digital tools, learning methods, and learning technologies (Figure 1). The implementation of the integrated approach is based on the use of information and communication technologies that enable the incorporation of educational modules, interdisciplinary connections, and digital resources into a unified managed system. This approach ensures the development of professional competencies required for work in the context of Industry 4.0, enhances the quality of training, and supports graduates' adaptation to rapidly changing professional environments.

The combination of an integrated approach with blended learning creates favorable conditions for intensifying the educational process and for the use of interactive methods, digital resources, and virtual laboratories. At the same time, this requires rethinking teaching methods, adapting teaching materials, and developing effective pedagogical strategies, which in turn creates the foundation for implementing an integrated approach to teaching the discipline.

Figure 1

Structure of methodological package for the discipline “ Modern Methods for the Study of Biological Objects ”.

<p><i>Educational content</i></p> <ul style="list-style-type: none"> • Lectures • Theoretical materials • Demonstration videos 	<p>Digital educational system</p>	<p><i>Digital tools</i></p> <ul style="list-style-type: none"> • Tests and surveys • Virtual laboratories • Video conferences
<p><i>Learning methods</i></p> <ul style="list-style-type: none"> • Projects • Simulation • Cases, situational tasks 		<p><i>Technologies and systems</i></p> <ul style="list-style-type: none"> • Cloud infrastructure • Local infrastructure • Colocation

Великий проміжок

Source: developed by the author

The integrated approach to teaching the discipline “MMSBO” combines knowledge from biology, physiology, genetics, chemistry, and physics. The implementation of this approach through the use of IT tools, including platforms for modelling biotechnological processes, visualization of molecular structures, and big data analysis in biomedicine, enables the analysis of biochemical processes in real or near-real environments. This facilitates the formation of a holistic perception of educational material and a deeper understanding of the biological principles. Such an



approach will contribute to the development of analytical thinking and prepares students to address complex professional tasks in a digital environment.

The integrated approach implies the cyclic and sequential nature of learning activities, in which each stage, from the acquisition of new knowledge to its practical application and reflection, is logically connected with the preceding one. A key element in the implementation of this approach to teaching the discipline “MMSBO” is the development of an electronic educational and methodological package for the discipline, which functions as a structured set of educational resources, services, and tools. The package integrates traditional didactic materials with digital components (multimedia content, interactive modules, and testing systems), ensuring the integrity of the educational process and supporting various learning scenarios.

The core element of the educational and methodological package is the course syllabus, which defines the aims and objectives of the course, the structure of content modules, the expected learning outcomes, and the range of competencies to be developed in students during the study of modern physical-chemical, molecular-biological, and bioinformatics methods for analyzing biological objects at the molecular, cellular, tissue, organ, and organism levels. The syllabus is supported through digital content navigation tools, hyperlinks, and integrated educational resources. Such integration promotes the development of practical skills in working with modern laboratory equipment and software used in biotechnology, biomedicine, pharmacology, ecology, and scientific research. In addition, the curriculum fosters the ability to rationally select optimal methods for studying biological objects to solve specific scientific and applied problems in industrial and pharmaceutical biotechnology.

The program learning outcomes of the working curriculum of the discipline “MMSBO” involve the development of a complex of professional competencies in future biotechnologists. A key role is played by professional and technical competencies, including the ability to operate high-tech equipment controlled by



computer systems, as well as to apply modern methods of bioengineering and nanobiotechnologies, ensuring readiness for work in contemporary laboratory and industrial environments. Analytical competencies are equally important, encompassing the ability to critically analyze data and make evidence-based decisions, thereby contributing to the development of critical thinking skills and the capacity to work with large-scale biomedical datasets. Communicative competencies also play a significant role and are developed through the exchange of experience and the use of digital libraries, facilitating integration into the global scientific and educational space. Thus, the professional competencies of master's-level biotechnologists ensure their readiness for work in high-tech production environments and for participation in international scientific collaboration.

Methodological materials for classroom work, including guidelines for lectures and practical classes, constitute an essential component of the educational and methodological package. They provide a structured presentation of educational material and highlight the key aspects of lectures and practical topics, thereby contributing to students' systematic understanding of the discipline. Methodological materials serve as tools for integrating theoretical knowledge with practical skills, as they include algorithms for laboratory procedures, examples of modern biotechnological methods, and assignments for independent work. Their use enables students to more effectively master the learning content, develop critical thinking, and enhance the ability to analyze complex biological processes. In addition, methodological guidelines facilitate the adaptation of the educational process to the digital environment by integrating multimedia resources, interactive simulations, and data visualization platforms. This creates conditions for the development of professional competencies required in biotechnology, including the ability to operate modern laboratory equipment, apply digital data analysis tools, integrate interdisciplinary knowledge, and implement innovative projects in high-tech pharmaceutical biotechnology production.



An equally important element of the integrated approach is the principle of knowledge visualization and structuring, which underlies the organization of classroom activities. Lecture content is organized through the use of multimedia technologies and data visualization tools such as Microsoft PowerPoint, Canva, and Google Slides, which enable effective visualization of information during lectures. The use of these technologies enhances students' information perception, as they are able to observe not only textual explanations but also dynamic diagrams, interactive models of cellular processes, and molecular structures. Multimedia presentations, interactive graphs, 3D models, and simulations help transform complex biological and biotechnological processes into clear and comprehensible visual representations for students. This creates conditions for the development of a holistic understanding of the learning material and a deeper grasp of biological patterns.

In addition, digital visualization during lectures enhances interactivity and student engagement, as learners can interact with educational materials in real time, analyze simulation results, and participate in group discussions. This approach not only increases motivation but also develops skills in working with modern information systems, which are essential for future professional activity in biotechnology. Digital presentations, video content, interactive schemes, and diagrams are used to facilitate the structuring of complex biochemical processes and optimize cognitive load. The integration of such tools with distance learning platforms enables the implementation of adaptive content delivery scenarios and enhances the effectiveness of knowledge acquisition. This approach contributes to the development of analytical abilities and interdisciplinary thinking, while also facilitating students' comprehension and retention of educational material.

One of the key principles of the integrative approach to teaching the discipline “MMSBO” is the practical orientation of learning. Practical classes in biochemistry are organized on the basis of clearly structured methodological guidelines that ensure the stepwise completion of tasks. The practical component of learning is



implemented through a combination of traditional laboratory classes and digital simulation tools. The use of cloud services and specialized software such as NCBI (National Center for Biotechnology Information), BLAST (Basic Local Alignment Search Tool) and PyMOL enables master's students to model the three-dimensional structures of proteins, identify homologous protein and DNA sequences, analyze genomes, and predict experimental outcomes prior to laboratory work. This approach integrates information technology competencies with fundamental biological knowledge. The use of virtual laboratories, interactive modules, and video instructions integrated into the distance learning platform (particularly through QR codes and hyperlinks to relevant video resources hosted on the LikarNMU distance learning platform) provides opportunities for reproducing experimental procedures in a digital environment. In particular, the Labster platform enables students to immerse themselves in complex biological systems under conditions close to real laboratory practice and to practice, for example, the polymerase chain reaction protocol or work with bioreactors without the high costs associated with laboratory equipment and reagents. The laboratory journal is presented in a hybrid format and includes a description of the methodology and experimental procedures, problem-oriented tasks, structured experimental protocols, control questions, as well as sections for recording research results and formulating conclusions, thereby contributing to the development of information management and interpretation skills. This format of learning provides students with the opportunity to model biotechnological and biomedical processes, develops their practical readiness for experimental research, fosters critical thinking, and enhances their motivation.

The integrative approach to teaching the discipline is implemented through the application of the active learning principle. The activation of learning activities is ensured through the use of interactive digital resources, including an electronic workbook for independent study (both classroom-based and extracurricular), testing systems (educational and methodological manuals containing test tasks and



explanations of correct answers), and video content, particularly via YouTube, where more than 140 demonstration videos are available. The use of such resources enhances the clarity, practical orientation, and accessibility of educational material, as well as supports reflective tasks (essays, analytical schemes, comparative tables), which facilitate students' independent work and contribute to increased motivation to study the methods related to biological objects. This learning format fosters critical thinking, develops professional competencies, and ensures the integration of theoretical knowledge with practical skills in a modern educational environment.

The system of knowledge assessment and evaluation within the integrated approach under blended learning conditions is implemented through the use of digital tools for monitoring and learning analytics. It includes both formative assessment (testing, mini-cases, online surveys) and summative assessment (final examination) using online testing tools such as Google Forms, Kahoot!, and Quizizz, as well as case-based tasks and automated assessment systems. These are implemented in a blended format combining written and online forms of assessment. Assessment is carried out according to clearly defined criteria that encompass the level of knowledge acquisition, the development of practical skills, and the formation of analytical thinking. The use of digital platforms makes it possible to perform prompt analysis of learning outcomes and to implement mechanisms of self-assessment and adaptive adjustment of the educational process. Educational analytics tools integrated into the distance learning platform of NMU provide the ability to monitor students' progress, level of content mastery, and individual learning trajectories. The use of such technologies creates conditions for the personalization of the educational process, as instructors gain access to detailed statistics on students' learning activities, achievements, and difficulties. This enables timely adjustment of teaching methods, adaptation of learning materials, and development of effective pedagogical strategies. Thus, digital monitoring and educational analytics tools serve not only as instruments of control but also as a powerful resource for the development of innovative



education focused on the integration of knowledge, practical skills, and digital literacy.

The use of digital tools in the study of the discipline is an important factor in the formation of students' professional competencies. These tools enable students to track their own progress, analyze learning outcomes, and adjust their educational trajectories in a timely manner. In addition, the integration of digital platforms into the learning process supports the development of independent learning skills, which is particularly important in the context of the rapid advancement of information technologies, where future specialists must be able to adapt to new challenges and use modern tools to solve professional tasks. Another important aspect is the personalization of learning: digital monitoring systems allow instructors to take into account individual student characteristics, levels of preparation, and pace of learning. As a result, a more flexible and effective educational environment is created, oriented towards the needs of higher education students.

Conclusions. Thus, the proposed model may be interpreted as a scalable digital educational system aimed at preparing specialists capable of functioning effectively under conditions of dynamic technological change. The use of digital technologies as a tool for implementing an integrated approach to the study of biochemistry ensures the formation of a holistic, manageable, and adaptive educational environment focused on the development of professional and digital competencies among students of higher pharmaceutical education, thereby enhancing their competitiveness in the context of digitalization.

The combination of the integrated approach with blended learning creates optimal conditions for intensifying and activating the educational process by ensuring the effective use of interactive methods, digital resources, and virtual laboratories. The implementation of such a strategy contributes to improving the quality of learning outcomes, fostering critical thinking, interdisciplinary analysis, and the development of independent problem-solving skills. This, in turn, leads to an



increased level of professional competence among future specialists who are capable of working effectively in modern enterprises in the pharmaceutical, food, and microbiological industries.

The combination of blended learning with the integrated approach should be regarded as an effective model for designing a digital educational environment that ensures the synergistic integration of educational content, pedagogical methods, and technological tools into a unified functional system. The implementation of such a strategy contributes to increasing the effectiveness of the educational process by optimizing access to information resources, structuring educational content, and supporting intensive interaction among participants in the educational process.

At the same time, the implementation of this approach necessitates the transformation of traditional pedagogical practices, the modernization of didactic models, the digitalization of teaching and methodological support, as well as the introduction of tools for the automation of educational processes. Further improvement of the integrated approach is associated with the implementation of artificial intelligence technologies, the use of adaptive educational platforms, and the development of interdisciplinary digital educational environments.

References

- [1] Ashraf M., Mollah S., Perveen S., Shabnam N., Nahar L. Pedagogical Applications, Prospects, and Challenges of Blended Learning in Chinese Higher Education: A Systematic Review. *Front Psychol.* 2022 Jan 25;12:772322. DOI: <https://doi.org/10.3389/fpsyg.2021.772322>
- [2] Balakrishnan A, Puthean S, Satheesh G, M K U, Rashid M, Nair S, Thunga G. Effectiveness of blended learning in pharmacy education: A systematic review and meta-analysis. *PLoS One.* 2021. DOI: <https://doi.org/10.1371/journal.pone.0252461>



[3] Nizhenkovska I., Kuznetsova O., Narokha V. Organising distance learning for master's in Pharmacy in Ukraine during COVID-19 quarantine: Innovation in teaching delivery or learning technology. *Pharmacy Education*, 2020. DOI: <https://doi.org/10.46542/pe.2020.202.5960>

[4] Istenič, A. Blended learning in higher education: the integrated and distributed model and a thematic analysis. *Discov Educ.* 2024. DOI: <https://doi.org/10.1007/s44217-024-00239-y>

[5] Castro Benavides LM, Tamayo Arias JA, Arango Serna MD, Branch Bedoya JW, Burgos D. Digital Transformation in Higher Education Institutions: A Systematic Literature Review. *Sensors (Basel)*. 2020. DOI: <https://doi.org/10.3390/s20113291>

[6] Möller H, Creutzfeldt J, Valeskog K, Rystedt H, Edelbring S, Fahlstedt M, Felländer-Tsai L, Abrandt Dahlgren M. Technology-Enhanced Learning of Human Trauma Biomechanics in an Interprofessional Student Context. *Teach Learn Med.* 2022. DOI: <https://doi.org/10.1080/10401334.2021.1893735>

[7] Yefremova O. Blended education in institutions of higher education (In Ukrainian). *Didactics*. 2023. DOI: <https://doi.org/10.58407/DIDACTICS.23.4-5.1>

[8] Altintas L, Sahiner M. Transforming medical education: the impact of innovations in technology and medical devices. *Expert Rev Med Devices*. 2024. DOI: <https://doi.org/10.1080/17434440.2024.2400153>.

[9] Raminpour S, Weisberg EM, Kauffman L, Fishman EK. Websites, mobile apps, and social media: Premier online educational tools for radiology. *Clin Imaging*. 2024. DOI: <https://doi.org/10.1016/j.clinimag.2024.110239>

[10] Li C, He J, Yuan C, Chen B, Sun Z. The effects of blended learning on knowledge, skills, and satisfaction in nursing students: A meta-analysis. *Nurse Educ Today*. 2019. DOI: <https://doi.org/10.1016/j.nedt.2019.08.004>.



- [11] Haftador AM, Tehranineshat B, Keshtkaran Z, Mohebbi Z. A study of the effects of blended learning on university students' critical thinking: A systematic review. *J Educ Health Promot.* 2023 DOI: https://doi.org/10.4103/jehp.jehp_665_22
- [12] Ge WL, Zhu XY, Lin JB, Jiang JJ, Li T, Lu YF, Mi YF, Tung TH. Critical thinking and clinical skills by problem-based learning educational methods: an umbrella systematic review. *BMC Med Educ.* 2025 DOI: <https://doi.org/10.1186/s12909-025-06951-z>
- [13] Pushkarova Y., Zaitseva G., Kaouthar B. Prediction of metabolism and solubility of tablet-form drugs according to the biopharmaceutical drug disposition classification system: Original scientific article. *ADMET and DMPK.* 2025. DOI: <https://doi.org/10.5599/admet.2945>
- [14] Kuchyn L., Vlasenko M., Gashenko A., Mykytenko V., Kucherenko I. Creating the informational and educational environment of the university based on the distance learning platform LIKAR_NMU. *Archives Of Pharmacy Practice.* 2021. DOI: <https://doi.org/10.51847/5zZerOAbwA>
- [15] O'Brien, R. (2001). An overview of the methodological approach of action research. In Roberto Richardson (Ed.), *Theory and Practice of Action Research [Teoria e Prática da Pesquisa Ação]*. João Pessoa, Brazil: Universidade Federal da Paraíba. (English version) Available: <http://www.web.ca/~robrien/papers/arfinal.html>