MODERN HIGHER BIOLOGICAL EDUCATION IN THE CONTEXT OF WAR: THEORETICAL AND PRACTICAL DISCOURSE (UKRAINIAN EXPERIENCE)

O ENSINO SUPERIOR BIOLÓGICO MODERNO EM CONTEXTO DE GUERRA: DISCURSO TEÓRICO E PRÁTICO (EXPERIÊNCIA UCRANIANA)

LA ENSEÑANZA BIOLÓGICA SUPERIOR MODERNA EN EL CONTEXTO DE LA GUERRA: DISCURSO TEÓRICO Y PRÁCTICO (EXPERIENCIA UCRANIANA)

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ABSTRACT: The purpose of the article is to analyze the theoretical and practical discourse of higher biological education in the conditions of hostilities and open Russian military aggression. Methods of analysis and synthesis, abstraction, comparison were used to implement the task. In the results of the study, the Ukrainian experience of organizing higher biological education during the martial law, the formation of opportunities for further development using the obtained best experience and potential European integration is updated. The main risks on the path of further development of higher biological education and prospects for further improvement of the general situation are highlighted. In particular, military challenges made it possible to develop higher biological education. In the conclusions, it is shown, that the regeneration of the field of education is possible against the background of the restoration of the administrative system in general.

KEYWORDS: Higher biological education. Russian-Ukrainian war. Transformations. Practical experience.

***RESUMO**: O objetivo do artigo é analisar o discurso teórico e prático da educação biológica superior nas condições de hostilidades e agressão militar russa. Métodos de análise e síntese, abstração e comparação foram utilizados para esse estudo. Nos resultados, a experiência ucraniana de organizar o ensino superior biológico durante a lei marcial, a formação de oportunidades de desenvolvimento adicional usando a experiência obtida e o potencial de integração europeia são atualizados. Salientam-se os principais riscos na via do desenvolvimento do ensino superior de biologia e as perspectivas de melhoria da situação geral. Em particular, os desafios militares permitiram desenvolver o ensino de biologia no nível superior. Nas conclusões, mostra-se que a regeneração do campo da educação é possível no contexto da restauração do sistema administrativo em geral.*

***PALAVRAS-CHAVE**: Ensino superior biológico. Guerra russo-ucraniana. Transformações. Experiência prática.*

***RESUMEN**: El objetivo del artículo es analizar el discurso teórico y práctico de la enseñanza biológica superior en las condiciones de las hostilidades y la agresión militar rusa. Para este estudio se utilizaron métodos de análisis y síntesis, abstracción y comparación. En los resultados se actualiza la experiencia ucraniana en la organización de la enseñanza superior biológica durante la ley marcial, la formación de oportunidades de desarrollo ulterior aprovechando la experiencia adquirida y el potencial de integración europea. Se destacan los principales riesgos en el camino hacia el desarrollo de la enseñanza superior biológica y las perspectivas de mejora de la situación general. En particular, los retos militares han permitido desarrollar la enseñanza de la biología a nivel superior. En las conclusiones, se demuestra que la regeneración del ámbito de la enseñanza es posible en el contexto de la restauración del sistema administrativo en general.*

***PALABRAS CLAVE**: Educación biológica superior. Guerra ruso-ucraniana. Transformaciones. Experiencia práctica.*

Introduction

The current development of the information society demonstrates new paradigms of educational development. First of all, we are talking about the globalization of education, its accessibility in different countries, the formation of multinational student and teaching teams, research groups, etc. These trends are extremely relevant for higher biological education since scientific research is internationalized, and it is extremely difficult to join the work without appropriate multicultural competence skills. On the other hand, an important aspect is the digitalization of education, which is inherent in all educational areas and specialties (BAKHMAT *et al.*, 2022). This aspect became especially important after 2020 when quarantine restrictions related to the global COVID-19 pandemic led to the dominance of innovative forms of distance learning. For higher biological education, this challenge was not easy, as much of the material planned in the syllabi of the disciplines had an important practical component. The implementation of curricula with this element in mind has become an extremely relevant subject for consideration (WOJCIECH *et al.*, 2021), as it allowed to establish certain general ideas about the organization of the educational process in the new conditions.

In Ukrainian realities, the problem of distance learning in higher biological education (and education in general) has also faced a military challenge. Russia's aggression against Ukraine has caused severe damage since 2014 when the Kremlin authoritarian regime seized the Crimean Peninsula and fomented separatist movements in other regions. At the same time, after the direct aggression in 2022, Ukrainian society suffered unprecedented destruction in the 21st century: destruction of infrastructure, demographic losses, general economic decline, etc. The destruction and temporary disorganization had an extremely negative impact on higher education (in particular, biology). Ways to overcome the consequences of this phenomenon are still underestimated in the scientific literature, as the war continues and may have even more negative consequences in the future.

So, the purpose of the article is to analyze the theoretical and practical discourse of modern higher biological education in the context of the ongoing war. The main objectives of the study are to actualize the Ukrainian experience of organizing higher biological education during martial law, the possibility of further development using the best practices and potential European integration.

Literature review

Today, many scholars are studying the peculiarities of organizing educational activities in the realities of military events. This is primarily due to the events of the Russian-Ukrainian war. However, educators have been interested in this issue before. In particular, Rajab (2018) in his empirical study investigated the problem of the effectiveness of digital learning in areas affected by military operations. Rajab (2018) analyzed educational technologies at the University of Najran (Saudi Arabia). Chankseliani, Qoraboyev and Gimranova (2020) studied the key aspects of the organization of higher education in Georgia against the background of Russian aggression, focusing on the analysis of education in the Russian-occupied Georgian territories (Abkhazia and South Ossetia). Malimon *et al*. (2022) characterized the current European trends in the transformation of higher education in the realities of military aggression (based on the Ukrainian experience). Kubitskyi *et al*. (2022) described some aspects of the management of modern pedagogical institutions in Ukraine. The peculiarities of using online learning against the background of the spread of various global challenges were studied by Dhawan (2020). At the same time, Jena, Gupta and Mishra (2021) conducted a comparative study of traditional face-to-face learning and the digital model of education. In their results, the authors proved that learning based on modern electronic and digital technologies is in no way inferior to traditional forms of education. Rani, Kaur and Sharma (2022) characterized the main opportunities and challenges for the further development of digital education in the future. Wojciech *et al*. (2021) described the digital learning resources of the future teacher, the features of their use. Bakhmat *et al*. (2022) highlighted the main opportunities for the digital transformation of the professional development of future teachers. The features of the use of modern educational technologies are investigated in the work of Huang, Spector and Yang (2022).

The main pedagogical conditions for the formation of digital literacy in biology teachers were identified by Ambarwati, Faizah and Rahayu (2019). At the same time, Lobach, Saenko and Isychko (2022) investigated the main advantages and disadvantages of using digital learning technologies. Metcalf, Bernacki and Bernacki investigated how digital learning platforms can be useful for biology students. The key aspects of using modern digital laboratories in the training of future biologists were characterized by Williamson (2020). Nourzaie, Mohammed and Batt (2020) studied the features of digitalization of the modern educational process. Organizational aspects of conducting classes with digital technologies, the process of forming classes using a blog as a virtual tool in teaching biology were described by

Županec, Lazarević and Pribićević (2022). Some principles of forming a research pedagogical text were outlined by Nehm (2019). At the same time, Jandrić (2021) described the transformation of biological education in accordance with modern market requirements. On the other hand, Oliveira *et al*. (2019) identified the main new educational technologies for teaching and learning science. Napal Fraile *et al.,* (2022) studied the formation of a modern biological text and ways of its distribution through the latest channels of digital information dissemination. However, the applied Ukrainian experience of organizing the educational process in higher biological education is poorly understood, although it contains certain useful elements for the development of the industry. For this reason, the characterization of the theoretical and practical discourse of digital biological education implementation is not fully realized.

Materials and methods

The analytical principle was used to determine the current state of biology teaching, describe the content of educational programs and methods used in the implementation of higher biological education. The work is also based on the method of abstraction (NOURZAIE; MOHAMMED; BATT, 2020), which involves the transition from the analysis of general theoretical positions to the formation of specific recommendations and generalizations (JANDRIĆ, 2021). The comparative method was used for a comparative analysis of educational approaches and methods used in Ukraine that will need to be changed in the framework of harmonization with the requirements of the educational systems of the European Union. The issue of introducing innovative technologies in the field of higher biological education was studied using the prognostic method.

Results

Elements of distance learning in times of war: first experience

The Russian aggression against Ukraine was a shock to the educational system, including the biology faculties of higher education institutions. Modern teaching is impossible without interactive learning and the use of information computer technologies and the development of the Internet. The use of innovative areas in the educational process makes it more interesting and diverse (ŽUPANEC; LAZAREVIĆ; PRIBIĆEVIĆ, 2022). For example, the Faculty of Biology of Ivan Franko National University of Lviv has developed and implemented progressive teaching methods and technical means to intensify students' cognitive

activity and use modern technologies. For example, the departments have created computer programs for self-preparation and control of knowledge of higher education students for each practical lesson, which include tests from the relevant control databases.

Improving the forms and methods of organizing the educational process and its methodological support will help to increase the effectiveness of learning and develop the professionalism of future biology specialists (NAPAL FRAILE *et al.*, 2022). In the context of military operations, the most attentive attitude to the learning needs of students has become an important aspect of the normalization of the educational process (NOURZAIE; MOHAMMED; BATT, 2018). Constant stress or staying outside of Ukraine has made it more important for higher education students to receive all the necessary information to continue their studies. Under such conditions, the location of teaching materials, research papers, assignments, etc. has become an important element of distance learning.

The modern era of social development and the pandemic have significantly accelerated the processes of education virtualization (HUANG; SPECTOR; YANG, 2019; RANI; KAUR; SHARMA, 2022). Even fields of knowledge that were previously considered less suitable for online learning have now moved to a new level of distance education technologies (JANDRIĆ, 2021). Biology faculty at almost all higher education institutions have made great efforts to use the capabilities of distance-learning platforms to create new and improve existing e-learning courses. Synchronous learning and regular monitoring are being used more actively, along with asynchronous learning methods, where higher education students can use the teaching and learning materials available in e-learning courses to prepare for classes, regardless of location, provided they have access to the Internet. The distance learning technologies that exist today are completely dependent on virtual learning environments (MALIMON *et al.*, 2022), the most popular of which is the Moodle environment. Its purpose is to ensure the effective organization of online learning. As the experience of the Faculty of Biology at Ivan Franko National University of Lviv has demonstrated, texts, glossaries, video and audio materials, tests, and other tools for student feedback are popular on the platform.

Quick interaction with this learning environment has revealed some challenges that need to be addressed. Our opinion is that the distance learning that was provided during the Russian invasion of Ukraine has a number of shortcomings, including:

1. Lack of contact between higher education students, although some distance learning platforms, such as Zoom or Google Classroom, provide this opportunity through video conferencing (NEHM, 2019). However, it is precisely the lack of communication between

students themselves that is at issue. According to modern learning paradigms, acquiring social skills is as important as acquiring hard skills. So, while the student-teacher relationship is functioning, the work between students themselves is less productive. Obviously, a gradual return to blended learning will be an adequate response to the military challenge, even despite all the physical threats.

2. Insufficient number of teaching and methodological complexes designed to meet the needs of distance learning, as well as their insufficient adaptation to this form of education. The COVID-19 pandemic has dealt a significant blow to the Ukrainian educational system, including higher biological education (JENA; GUPTA; MISHRA, 2021). Distance learning is much less adapted to the development of practical skills than to the acquisition of theoretical knowledge. The problem has gradually been solved through the use of digital platforms with relevant tasks and methodological content. Russian aggression has again pushed practical training opportunities back to the level of early 2020. Only when Ukraine's overall situation was fixed at a crisis, but stable level did it become possible to return to combined training and the use of the practical component.

3. Lack of quality technical support, in particular, due to poor Internet, outdated equipment, and limited availability of equipment at home. The military factor has put pressure on communication systems. Overloading, destruction of communications and related infrastructure, radio interference, etc. have made it difficult to attend classes even remotely. Some teachers and many students of higher biological education found themselves abroad, where it was not always possible to attend classes.

4. The psychological factor has become important. Military destruction and threats to physical life and health pushed educational issues into the background. The state of shock across Ukraine in frontline cities turned into a major psychological challenge. As a result, higher education institutions, which also provided biology education at the appropriate level, were forced to establish personal contacts with each student. Thanks to the successful organization, future biology specialists were able to survive the shock and return to their studies. At the same time, many higher education students refused to continue their studies due to the impossibility of returning to normal life.

Ways of further development of higher biological education

Although the Ukrainian system of higher biological education suffered significant damage due to the armed invasion, it has survived. The authorities and university administrations were partly able to make effective decisions to stabilize the system under such difficult conditions. The cohesion of the Ukrainian teaching community, the motivation to continue studying and teaching, and the fairly effective internal policies of Ukrainian higher education institutions were of great importance in this process. Representatives of the international community have been invaluable in providing assistance to Ukrainian universities.

In the future, there is a need to develop the content and conceptual vision of the restoration and transformation of the higher biological education system, taking into account the consequences of the war (BAKHMAT *et al*., 2022). The highest priority task of recovery is to restore those educational institutions that have suffered significant material, human, and organizational losses as a result of the Russian armed invasion. However, the principles of biology education should be transformed. Today, the conditions are right for making important, often difficult decisions (METCALF; BERNACKI; BERNACKI, 2022). Ukraine is trying to identify a list of measures and tasks that need to be implemented to restore and transform its higher education system. To this end, a great deal of work is being done to identify and record the damage that higher education institutions and educators have suffered, as well as the possibilities of overcoming it. First of all, we are talking about the possibilities of borrowing the best European and world experience in the functioning of the field of higher biological education. Some aspects of this process can be summarized in a short list (See Table 1).

Table 1 – Ways to transform higher biological education in Ukraine

	Feature	Characteristic
1	Integration	Higher biological education today widely uses an interdisciplinary approach that involves integration with other sciences, such as physics, chemistry, mathematics, computer science, ecology, and others (RAKHIMOV; MUKHAMEDIEV, 2022). This helps students understand how the biological sciences are related to other fields of science and technology. There may be a need to develop integrated courses that would allow students to master not only biology knowledge but also computer modeling, reagent handling, etc. This would optimize the education system, making it more flexible and modern.
2	Use of digital technologies	Global higher education in biology is now focusing on environmental issues such as biodiversity conservation, climate change (CHRÁSKOVÁ; CHRÁSKA, 2021), the use of sustainable materials, and other aspects related to environmental preservation. This global trend will also need to be developed in Ukraine, where environmental issues have long remained unresolved. Russia's military aggression has only actualized environmental challenges, so this area will become important in the near future.

3	Use of digital technologies	In the world, higher biological education in the current state includes the use of the latest technologies, such as genetic engineering, biotechnology, molecular biology, computed tomography, and others (WILLIAMSON, 2020; ŽUPANEC; LAZAREVIĆ; PRIBIĆEVIĆ, 2022). This helps students gain a deeper knowledge and understanding of biology (AMBARWATI; FAIZAH; RAHAYU, 2019). In Ukrainian realities, due to lack of funding, this area has been implemented only partially. There may be a need to concentrate state, international, and private support to the best Ukrainian universities.
4	Development of soft skills	In the Ukrainian education system in general, and in higher biological education in particular, the focus has been on hard skills. At the same time, in the current conditions of social development, biology is developing in multicultural research teams (NAPAL FRAILE *et al*., 2022). For the formation of such centers in Ukraine, as well as for the proper work of future biology specialists in other countries, obtaining sufficient multicultural competence is extremely important (OLIVEIRA *et al*., 2019; DHAWAN, 2020). In addition, higher biological education today is tasked with developing students' critical thinking, including the ability to analyze data, draw conclusions based on scientific evidence, and solve complex problems.

Source: Prepared by the authors

Practical implementation of these decisions is possible with government support. In particular, at the end of 2022, the Government of Ukraine presented the Education 4.0: Ukrainian Dawn program developed by the Ministry of Education and Science. The developers claim that the program is based on the principles of the Recovery Plan and aims to create an education system that will be harmonized with European educational standards and meet the requirements of human resources in Industry 4.0 over the next ten years.

The program includes several goals, objectives, and indicators of their implementation in the field of higher education and science. The main objectives are to focus on post-war reconstruction, increase confidence in the educational, scientific, and expert activities of universities, and create a modern network and state-of-the-art higher education infrastructure. The latter goal is expected to be achieved by optimizing the network of universities through their mergers and consolidation, as well as the creation of new laboratories and the reconstruction of dormitories. Indicators of achieving this goal include the creation of 2,000 new laboratories and the reconstruction of 200 dormitories, which is possible through the attraction of funds through public-private partnerships, private capital and business, and international assistance. International assistance and the interest of foreign businesses in Ukrainian research projects should probably be decisive in financing such transformations.

Discussion

The functioning of higher education in biology under martial law has faced a number of challenges that have been summarized by many researchers. The solution to the difficulties and the way out of the difficult situation is seen in the wider use of digital technologies, the introduction of a blended learning system, and innovative technologies. While the concept of blended learning is fully consistent with the Ukrainian realities of today and is actively used, the deployment of digitalization of education while military operations continue poses certain threats. The digitalization of the educational process against the backdrop of Russian aggression has demonstrated additional vulnerability, which has also become evident in the functioning of biology faculties. The organization of distance learning and E-learning, in general, requires the stable availability of electronic resources, primarily e-learning systems, e-journals, electronic document management systems, library resources, and other digital tools running on the server equipment of higher education institutions (RAJAB, 2018; LOBACH; SAENKO; ISYCHKO, 2022). Before the war, Ukrainian higher education institutions, including the relevant biology faculties, did not practice re-hosting critical information on “mirror” servers that would be physically located in other regions of Ukraine or even in neighboring countries. This did not happen for various reasons, including high costs and technological problems with implementation. For this reason, many of the displaced universities began to take this issue more seriously, as there was a high risk of losing access to important electronically stored information. Some administrators of biology faculties were able to transfer important information to other servers via Internet channels, and some managed to move some computer and server equipment to a safe area. Thus, the need for additional computer and server equipment remains high for displaced educational institutions.

Innovative methods of organizing the educational process remain important, which in the field of biology is effectively combined with the project method (MALIMON *et al*., 2022; METCALF; BERNACKI; BERNACKI, 2022). This teaching strategy involves students learning independently by solving real-world problems. With the project-based method, students develop their own projects based on a specific problem in biology and investigate it using the scientific method, collecting and analyzing data, drawing conclusions, and presenting their results (KUBITSKYI *et al*., 2022). This method allows for the development of independent work, research, presentation, and communication skills, and it is well-suited to distance learning.

The search for the next methods to improve higher biology education will also lead to a revision of certain established paradigms in teaching. One update has been actively implemented since the COVID-19 pandemic, namely distance learning and the overall digitalization of the educational process. At the same time, teaching methods also require active changes, which will have to be aimed at establishing a new level of relationship between teachers and students. First and foremost, it is about mutual respect and the ability to interest students, which has been partially confirmed in research. This, for example, helps students to develop an internal motivation for learning, which partially allows them to focus on the realities of wartime.

Conclusions

Thus, higher biological education during the hostilities suffered a devastating impact (as did the educational system in general) but continued to function. Thanks to the experience of working with distance education, the training was transferred to online mode. Obviously, the first experience was the most shocking. As practical steps have shown, prompt response, establishing contacts with students, switching to interactive learning, and the use of information computer technology and the Internet have had a positive effect. We are talking even about such simple steps as creating computer programs for self-study and knowledge control of higher education students, electronic library of departments, access to test tasks, lecture materials, which helps to reduce the time spent searching for the necessary information. The next step was to use the capabilities of cloud-based learning environments to create new and improve existing e-learning courses. As a result of the difficulties in organizing synchronous training, asynchronous training methods were also introduced. However, the military challenge makes it possible to further develop higher biological education in the direction of integration, sustainability, use of digital technologies, and development of social skills. Against the backdrop of the destruction of the old educational infrastructure, the industry may be reborn. A promising vector for further research, given the challenges and possible achievements of higher biological education in Ukraine, is the integration of biology with other fields of science to better utilize the scientific and scientific-pedagogical potential of the field.

REFERENCES

AMBARWATI, R.; FAIZAH, U.; RAHAYU, D. A. Enhancing the digital literacy of pre-service biology teacher through animal systematics course. *In*: PROCEEDINGS OF THE MATHEMATICS, INFORMATICS, SCIENCE, AND EDUCATION INTERNATIONAL CONFERENCE, 2019, Surabaya, Indonesia. **Proceedings** [...]. Paris, France: Atlantis Press, 2019. ISBN 9789462528741. DOI: 10.2991/miseic-19.2019.46.

BAKHMAT, N. *et al.* Modernization of future teachers' professional training: on the role of immersive technologies. **Futurity Education**, v. 2, n. 1, p. 28-37, 2022. DOI: 10.57125/fed/2022.10.11.22.

CHANKSELIANI, M.; QORABOYEV, I.; GIMRANOVA, D. Higher education contributing to local, national, and global development: new empirical and conceptual insights. **Higher Education**, v. 81, n. 1, p. 109-127, 2020. DOI: 10.1007/s10734-020-00565-8.

CHANKSELIANI, M.; QORABOYEV, I.; GIMRANOVA, D. Higher education contributing to local, national, and global development: new empirical and conceptual insights. **Higher Education**, v. 81, n. 1, p. 109-127, 2020. DOI: 10.1007/s10734-020-00565-8.

CHRÁSKOVÁ, M.; CHRÁSKA, M. Availability of implementation of standards of digital competence of secondary education teachers. **Futurity Education**, v. 1, n. 1, p. 32–40, 2021. DOI: 10.57125/FED.2022.10.11.4.

DHAWAN, S. Online learning: A panacea in the time of COVID-19 crisis. **Journal of Educational Technology Systems**, v. 49, n. 1, p. 5-22, 2020. DOI: 10.1177/0047239520934018.

HUANG, R.; SPECTOR, M.; YANG, J. **Educational technology: a primer for the 21st century**. [*S. l.*]: Springer, 2019. 248 p. ISBN 9789811366420.

JANDRIĆ, P. Biology, information, society. **Postdigital Science and Education**, v. 3, n. 2, p. 261-265, 2021. DOI: 10.1007/s42438-021-00220-0.

JANDRIĆ, P. Biology, information, society. **Postdigital Science and Education**, v. 3, n. 2, p. 261-265, 2021. DOI: 10.1007/s42438-021-00220-0.

JENA, B.; GUPTA,S.; MISHRA, N. Effectiveness of online learning and face-to-face teaching pedagogy. *In*: JENA, B. M.; GUPTA, S. L.; MISHRA, N. **Transforming higher education through digitalization**. Boca Raton: CRC Press, 2021. p. 21-43. DOI: 10.1201/9781003132097-2.

KUBITSKYI, S. *et al.* Management of pedagogical and sports educational institutions in Ukraine. **SPORT TK-Revista EuroAmericana de Ciencias del Deporte**, v. 11, p. 19, 2022. DOI: 10.6018/sportk.538991.

LOBACH, N.; SAENKO, M.; ISYCHKO, L. Disadvantages and advantages of implementing distance learning in higher institutions of medical education. Viae Educationis. **Studies of Education and Didactics**, v. 1, n. 3, p. 13-18, 2022. DOI: 10.15804/ve.2022.03.01.

METCALF, L.; BERNACKI, M.; BERNACKI, L. How do digital textbook platforms promote active learning in undergraduate biology courses? **Journal of Research in Science Teaching**, DOI: 10.1002/tea.21845.

NAPAL FRAILE, M. *et al.* Digital narratives for biology learning. *In*: NAPAL FRAILE, M. *et al.* **Contributions from biology education research**. Cham: Springer International Publishing, 2022. p. 87-98. DOI: 10.1007/978-3-030-89480-1_7.

NEHM, R. Biology education research: building integrative frameworks for teaching and learning about living systems. **Disciplinary and Interdisciplinary Science Education Research**, v. 1, n. 1, 2019. DOI: 10.1186/s43031-019-0017-6.

NOURZAIE, H.; MOHAMMED, T.; BATT, M. Digital learning: the future of medical education? **The Clinical Teacher**, v. 15, n. 4, p. 353, 2018. DOI: 10.1111/tct.12810.

OLIVEIRA, A. *et al.* Emerging technologies as pedagogical tools for teaching and learning science: a literature review. **Human Behavior and Emerging Technologies**, v. 1, n. 2, p. 149-160, 2019. DOI: 10.1002/hbe2.141.

RAJAB, K. The effectiveness and potential of e-learning in war zones: an empirical comparison of face-to-face and online education in Saudi Arabia. **IEEE Access**, v. 6, p. 6783-6794, 2018. DOI: 10.1109/access.2018.2800164.

RAKHIMOV, T.; MUKHAMEDIEV, M. Peculiarities of the implementation of the principles of the education of the future analysis of the main dilemmas. **Futurity Education**, v. 2, n. 3, p. 4–13, 2022. DOI: 10.57125/FED/2022.10.11.29.

WILLIAMSON, B. New digital laboratories of experimental knowledge production: artificial intelligence and education research. **London Review of Education**, v. 18, n. 2, 2020. DOI: 10.14324/lre.18.2.05.

WOJCIECH, W. *et al.* **Future educator's digital learning assets**: global challenges of our time. Futurity Education, v. 1, n. 2, p. 32-41, 2021. DOI: 10.57125/fed/2022.10.11.17.

ŽUPANEC, V.; LAZAREVIĆ, T.; PRIBIĆEVIĆ, T. Classes supported by digital technologies: the application of the blog as a virtual tool in biology teaching. **Inovacije u nastavi**, v. 35, n. 3, p. 120-133, 2022. DOI: 10.5937/inovacije2203120z.

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