THE USE OF INNOVATIVE TECHNOLOGIES IN EDUCATION: ANALYSIS OF EFFECTIVENESS AND IMPLEMENTATION AT DIFFERENT LEVELS OF EDUCATION

O USO DE TECNOLOGIAS INOVADORAS NA EDUCAÇÃO: ANÁLISE DA EFICÁCIA E IMPLEMENTAÇÃO NOS DIFERENTES NÍVEIS DE EDUCAÇÃO

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Abstract. Integrating innovative technologies into the educational process can significantly enhance students' understanding and engagement with the subject matter. The article deals with the issue of innovative educational technologies implementation into biology teaching at different levels of education. The paper aims to research the most used and effective innovative technologies for biology teaching in Ukrainian education establishments. To achieve the aim of the research, a set of methods was used: theoretical: analysis of psychological, pedagogical, and methodical sources; empirical: questionnaires, interviews; graphics. The research results have found that students get an opportunity to solve a number of academic problems in the course of modern educational technologies using. It has been revealed that the most effective innovative technologies for biology teaching in Ukrainian education institutions are simulation software, virtual reality and augmented reality, online laboratories, gamification, online collaborative platforms, mobile apps, personalized learning platforms, data analysis tools, and biotechnology kits. The results show that mostly young teachers (1-10 years of work experience) implement modern education technologies. The research made it possible to determine the most effective mobile applications for learning biology that are designed to provide students with interactive and engaging ways to learn biology concepts on their smartphones and tablets. The results point to the online collaborative platforms that are most used in the educational process: Google Workspace for Education (secondary education) and Moodle (higher education).

Keywords: higher education innovative technologies, education for sustainable development, intending biology teachers training, education level.

Resumo. A integração de tecnologias inovadoras no processo educacional pode melhorar significativamente a compreensão e o envolvimento dos alunos com o assunto. O artigo trata da questão da implementação de tecnologias educacionais inovadoras no ensino de biologia em diferentes níveis de ensino. O artigo tem como objetivo pesquisar as tecnologias inovadoras mais utilizadas e eficazes para o ensino de biologia em estabelecimentos de ensino ucranianos. Para atingir o objetivo da pesquisa, utilizou-se um conjunto de métodos: teóricos: análise de fontes psicológicas, pedagógicas e metódicas; empírico: questionários, entrevistas; gráficos. Os resultados da pesquisa descobriram que os alunos têm a oportunidade de resolver uma série de problemas acadêmicos no curso de tecnologias educacionais modernas. Foi revelado que as tecnologias inovadoras mais eficazes para o ensino de biologia nas instituições de ensino ucranianas são software de simulação, realidade virtual e realidade aumentada, laboratórios online, gamificação, plataformas colaborativas online, aplicativos móveis, plataformas de aprendizagem personalizadas, ferramentas de análise de dados e kits de biotecnologia. . Os resultados mostram que a maioria dos professores jovens (1 a 10 anos de experiência profissional) implementam tecnologias educativas modernas. A pesquisa permitiu determinar os aplicativos móveis mais eficazes para o aprendizado de biologia, projetados para fornecer aos alunos formas interativas e envolventes de aprender conceitos de biologia em seus smartphones e tablets. Os resultados apontam para as plataformas colaborativas online mais utilizadas no processo educativo: Google Workspace for Education (ensino secundário) e Moodle (ensino superior).

Palavras-chave: tecnologias inovadoras no ensino superior, educação para o desenvolvimento sustentável, formação de professores de biologia, nível de ensino.

INTRODUCTION

Nowadays, there is a great number of educational changes in Ukraine. Despite military operations in the country, we build new modern conceptual foundations of the national education system. The process of national education integration into the European educational space takes place regardless of the difficult contemporary conditions of danger to the population of our state.

The necessity to renovate the educational field of Ukraine is due to its insufficient compliance with the modern demands of society. The modernization of an intended teacher training process involves increasing the requirements for their professional level to implement the New State Education Standard. To reform the educational sector, it is necessary to train competent teachers of the new generation, who can act productively and purposefully in modern conditions. Considering this, the issue of implementing innovative technologies while studying at educational institutions is relevant.

Most of the educational institutions in Ukraine today conduct educational processes in a mixed or distance format. The COVID-19 pandemic caused the largest disruption to education in history ... Most education systems were unprepared, leaving one-third of learners without access to any remote learning and highlighting the urgency of equipping teachers with the requisite digital and pedagogical skills [UNESKO].

Numerous works have been devoted to the issue of innovative educational technologies implementation (Bılyk, Yashchuk, Marchak, Tkachenko, & Goncharova, 2021; Feitosa & Dias, 2019; O'Flaherty & Liddy, 2018; Lin, Wu, Wang, Pedaste, & Huang, 2022; Rudyshyn, Koreneva, Yakushko, Babenko-Zhyrnova, & Lupak, 2022; Sari, Wulan, & Solihat, 2019; Sebastian-Lopez & de Gonzalez, 2020; Sidorovich et al., 2022 etc.) To our mind, the most relevant are the works in which this problem is developed in the context of implementing modern educational technologies with the purpose to provide the younger generation with a solid groundwork to solve the problem of sustainable development of our planet.

Therefore, the purpose of the study is to present the experience of using innovative educational technologies during biology teaching at different levels of education (Zinovieva et al., 2021).

Paper presented at the Journal of Physics: Conference Series, , 1840(1) doi:10.1088/1742-6596/1840/1/012029). As a rule, scientists focus their attention on one or two innovative technologies. In contrast to them, we aimed to investigate educational technologies that are most used in the process of teaching biology in educational institutions in Ukraine.

LITERATURE REVIEW

Scientific and methodological literature contains a certain amount of research on innovative educational technologies implementation into biology teaching. Among them, the main ones are the introduction of technologies for the simulation of students' educational process and professional training (Rudyshyn et al., 2022); understanding education for sustainable development (Grund & Brock, 2020); (Molderez & Fonseca, 2018); (Hartadiyati, Wiyanto, Rusilowati, & Prasetyo, 2020); (O'Flaherty & Liddy, 2018); assessment of online learning (Alpert, Couch, & Harmon, 2016).

S. Lee and C. Tsai (2013) carried out a literature review of using modern educational technologies in teaching biology during the previous decade. They research the process of utilizing simulations or visualization means. They outline that the most popular biological topics are genetics and molecular biology.

M. Akçayır, G. Akçayır, H. Pektaş, & M. Ocak (2016) study the effectiveness of augmented reality as a means of improving university students' laboratory skills and attitudes toward scientific laboratories.

C. Lin et al. (2022) explore collaborative learning strategies that are often used in STEAM transdisciplinary education to train students' problem-solving skills. V. Bılyk et al. (2021) have proved the necessity to define ultra-innovation educational technologies, contributing to the rising psychology students' motivation to study biology. They have characterized such pedagogical technologies: as coworking, Barcamp, workshop, SMART technology, and BYOD technology.

In the other study (J. Sun et al., 2023) the impact of implementing different teaching tools (paper textbooks, wearable AR material, and wearable hybrid AR/VR material) in physics studying on the situational engagement, and successful learning of school students was hypothesized. The research results demonstrated that the situational engagement and successful learning of the wearable hybrid AR/VR group were much higher than in the traditional learning group. This study concludes that teachers can use

wearable hybrid AR/VR to increase situational engagement and successful learning among education seekers in science laboratory educational environments.

Numerous researchers suggest virtual reality use as a productive educational means for natural science teaching: involving undergraduates in a library guide by means of video-based wearable spherical virtual reality (H. Lin et al. (2019); three-dimensional virtual reality trips provide the opportunity to learn about climate change (D. Markowitz et al. (2018); teaching natural science through immersive virtual reality (Parong & Mayer (2018); collective intelligence and consciousness to engage students through real-time virtual reality creation (Wang & Sun, 2021). M. Rojas-Sánchez, P. Palos-Sánchez, & J. Folgado-Fernández (2023) present scientific sources analysis on virtual reality in education.

A group of scientists (B. Anđić et al. (2023) maintain a study of teachers' STEM views on implementing three-dimensional modelling and printing (3DMP) in teaching and prove that 3DMP use in STEM teaching enriches students' competence, motivation, and active participation in the educational process.

In recent years, there has been growing interest in different aspects of virtual reality implementation, in particular: methods of using virtual reality in education for industry and sustainability (A. Paszkiewicz, et al., 2021); analysing the virtual reality technologies based on mathematical biosciences and engineering (Palos-Sanchez, et al., 2022); a VR educational system for construction workers' competences developing (F. Osti, et al., 2021); a scientific literature exploration of successful e-learning through social virtual reality conditions at a higher education institute (Mystakidis, Berki, & Valtanen, 2021; Iatsyshyn, Kovach, Romanenko, & Iatsyshyn, 2019); implementing augmented reality and the structure of the functional model to teach behaviour school pupils (Gnidovec, Zemlja, Dolenec, & Torkar, 2020); virtual and distant laboratories in education for control (Heradio, de la Torre, & Dormido, 2016).

A growing body of literature has studied various modern technologies for teaching natural sciences: examining go-lab based in understanding teacher design practices for digital inquiry-based science learning (T. de Jong, et al., 2021); factors that affect students' choosing of technology means during biology learning (Cairns, Dickson, & McMinn, 2021); investigation of thinking practices and epistemic actions to search students' comprehension of genetics and evolution (Ageitos, Puig, & Colucci-Gray, 2019); methodology and epistemology of computer simulations and implications for science education (M. Develaki, 2019); comparing middle school students' science explanations during physical and virtual laboratories (D. Gnesdilow & S. Puntambekar, 2021); fostering middle school students' knowledge integration using the Web-based inquiry science environment (B. Ulus & D. Oner, 2020); a pedagogical perspective of understanding how the perceived usefulness of mobile technology impacts physics learning achievement (X. Zhai & L. Shi, 2020); the impact of Physics education technology interactive simulation-based learning on motivation and academic achievement among malawian physics students (Banda, & Nzabahimana, 2023; Bakhov, Opolska, Bogus, Anishchenko, & Biryukova, 2021).

AIMS

The analysis of the above-mentioned scientific literature gives reason to assert that different aspects of the searched issue have been studied quite thoroughly. However, given the constant rapid change of the world of innovations, it is worth noting the need to study new educational technologies that are constantly updated and improved. Therefore, this paper aims to research the peculiarities of innovative educational technologies usage in the process of teaching Natural sciences at educational institutions in Ukraine.

To achieve the general research aim, we should realize the following tasks in stages: 1) to determine the most effective innovative educational technologies for teaching biology at different educational levels; 2) to study the current state of simulation software and mobile applications usage to study natural sciences in Ukrainian educational establishments; 3) to make a rating of online collaborative platforms for learning biology according to the frequency of use in educational institutions of Ukraine.

METHODS

To achieve the purposes of the research, a set of methods of data collection was used: theoretical: analysis of scientific and methodical sources; empirical: observation of the educational process, questionnaires, interviews, conversation and focused group discussion; statistical; graphic.

Primary data was collected with the help of a questionnaire, brainstorming sessions, and expert surveys. 178 biology teachers of different education levels participated in the questionnaire. The study found that Ukrainian biology teachers have positive views toward using innovative technologies in the educational process of natural sciences.

Secondary data was collected from leading research databases, articles and other secondary sources. So, to complete a detailed understanding of the issue, we analysed scientific sources according to modern education technologies. In the paper principles, meeting procedures to identify supplementary information addressing the factors related to the subject of this study were determined. Therefore, our search resulted in the identification of the most critical elements of innovative technologies in higher education today. Furthermore, we implemented a survey to understand the view of the teachers' community regarding modern technology usage. Before conducting the survey, we advised experienced specialists to ensure that the examination is sufficient, satisfactory, and appropriate. We adapted the study survey according to their expert views, including proper variables for the investigation and excluding some traditional or irrelevant elements.

The methodology of expert assessment was implemented to rate online collaborative platforms as a means of teaching. To ensure the reliability of the obtained data, independent competent experts of the same qualification (everybody has PhD and Biology teaching experience of more than 5 years) from the teaching staff of education institutions were involved. Compliance with the requirement of probability was aimed at equalizing the basic conditions for conducting a pedagogical experiment in the real conditions of the educational process. In the process of organizing the experimental work, the complexity and multicomponent nature of the biology teaching process were taken into account.

RESULTS AND DISCUSSION

The hypothesis of the research predicted that the introduction of innovative technologies for Natural Sciences educational training will have positive consequences for further students' development activity.

The results of a survey of teachers made it possible to identify summarized data of the main innovative educational technologies used to enhance the teaching and learning of biology today in education institutions in Ukraine (table 1).

Table 1. Modern Educational Technologies for Natural Sciences Teaching in Ukraine.

Innovative educational technologies	Functioning and advantages of innovative technology
Virtual Reality (VR) and Augmented Reality (AR)	VR and AR technologies allow students to immerse themselves in virtual environments that replicate biological processes, cellular structures, ecosystems, and even virtual dissection. These technologies offer a more engaging and interactive learning experience, enabling students to visualize complex concepts in biology.
Simulation Software	Simulation software allows students to experiment with biological processes and systems virtually. They can manipulate variables and observe the outcomes, aiding in the understanding of various biological phenomena, such as evolution, genetics, and ecological interactions.
Online Laboratories	Virtual labs provide students with the opportunity to perform experiments and collect data in a simulated lab environment. These online laboratories offer a cost-effective and accessible alternative to traditional hands-on labs, allowing students to explore various concepts in biology.
Gamification	Gamification involves incorporating game elements, such as badges, points, and leaderboards, into the learning process. By using gamified educational platforms, teachers can make biology learning more enjoyable and motivating for students, enhancing their engagement and knowledge retention.

Interactive Whiteboards and Smartboards	Interactive whiteboards and smartboards enable teachers to present biology content more dynamically. They can integrate multimedia elements, annotate visuals, and interact with digital content, fostering a more interactive and visually appealing learning experience.
Online Collaborative Platforms	Online collaborative platforms facilitate real-time communication and group work among students. These platforms enable biology classes to collaborate on projects, discuss complex topics, and share knowledge beyond the confines of the classroom.
Mobile Apps	Biology-related mobile apps provide students with on-the-go access to interactive quizzes, flashcards, and educational resources. These apps encourage self-directed learning and help reinforce biological concepts outside the classroom.
Personalized Learning Platforms	AI-powered personalized learning platforms can assess individual student strengths and weaknesses in biology and offer tailored learning materials and exercises to address their specific needs. This adaptive learning approach enhances student understanding and progress.
Data Analysis Tools	Data analysis tools allow students to explore biological datasets and draw insights from real-world data. These tools are particularly beneficial for teaching bioinformatics, computational biology, and data-driven biology research.
Biotechnology Kits	Biotechnology kits provide students with hands-on experience in genetic engineering and molecular biology techniques. These kits allow students to perform experiments safely and learn essential laboratory skills.

Source: compiled by the authors.

Unfortunately, in today's conditions in Ukraine, it is not possible to use all the above-mentioned innovative technologies, which is proven by the results of questionnaires and surveys. No more than 3 innovative technologies are used in each educational institution.

Educators need to keep up with the latest advancements in educational technology to provide the best learning experience for their students.

The next step of the research was a survey of teachers to identify the number of teachers who use at least 1 of the specified innovative technologies. The results of the survey of teachers of various educational levels are presented in Table 2 and in Figure 1.

Table 2. Division of Teachers Who Use Innovative Educational Technologies for Biology Teaching.

Level of education	**Group 1 (1-4 years of work experience)**	**Group 2 (5-10 years of work experience)**	**Group 3 (11-25 years of work experience)**	**Group 4 (< 25 years of work experience)**
General secondary education	31 %	36 %	21 %	12 %
Vocational secondary education	38 %	39 %	16 %	7 %
Bachelor's level of higher education	33 %	35 %	18 %	14 %
Master's level of higher education	31 %	41 %	23 %	5 %
Average value	**33,25 %**	**37,75 %**	**19,5 %**	**9,5 %**

That is, we can conclude that modern biology teaching technologies are most often used by young teachers with up to 10 years of work experience, regardless of the level and educational institution in

which they work. Instead, a rather small percentage of teachers with more than 25 years of work experience use innovative technologies in the process of teaching biology.

The questionnaire of biology teachers show that one of the most effective technology is simulation software. There are various simulation software used in Ukraine for learning biology. However, the specific simulation software used in education can vary depending on the institutions and individual preferences of educators. Conversations and the questionnaire of biology teachers make it possible to rate them according to the usage frequency in the process of teaching natural sciences.

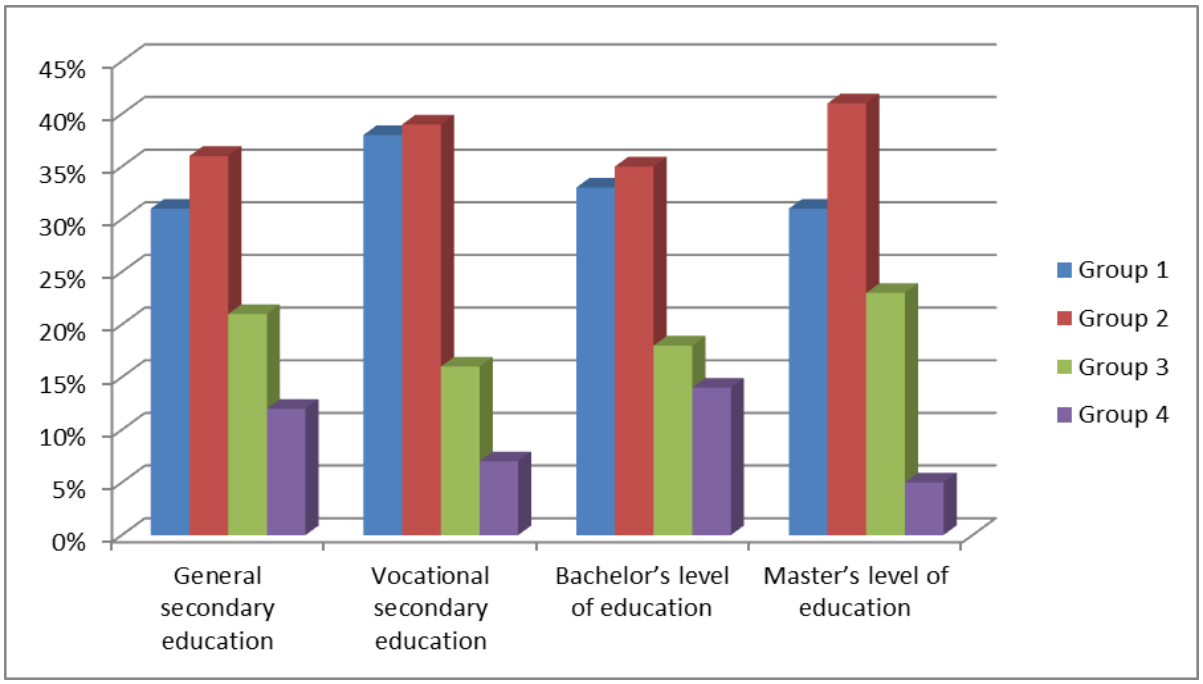

Figure 1. Division of Teachers Who Use Innovative Educational Technologies for Biology Teaching in Ukraine.

Table 3. Simulation Software for Natural Sciences Teaching in Ukraine.

Rating	Simulation Software	Functioning and advantages
1	Biology Simulators	These simulators allow students to explore various biological processes and concepts in a virtual environment. They can simulate cellular processes, genetics, evolution, ecology, and more. Students can manipulate variables and observe the outcomes of different scenarios, aiding in their understanding of complex biological phenomena.
2	Ecology and Environmental Simulations	Ecology simulations allow students to study ecosystems, environmental interactions, and population dynamics. They can explore how changes in environmental factors impact species and ecosystems over time.
3	Virtual Dissection Software	Virtual dissection software provides a digital alternative to traditional dissection in biology classes. Students can virtually dissect specimens, explore anatomical structures, and learn about the different systems within organisms.
4	Bioinformatics Tools	Bioinformatics software helps students work with biological data, including DNA sequences, protein structures, and gene expression data. These tools enable students to analyze and interpret biological data, making connections between genetics and various biological processes.
5	Evolutionary Simulation Software	Evolutionary simulation tools help students understand the principles of natural selection, genetic variation, and speciation. Students can simulate evolutionary processes and observe how traits change in populations over generations.

6	3D Molecular Modeling Software	These tools enable students to visualize and manipulate molecular structures, such as proteins and DNA, in three dimensions. It helps students understand the structural basis of biological functions.
7	Biotechnology Simulations	Biotechnology simulations allow students to explore genetic engineering techniques and molecular biology processes. They can experiment with DNA manipulation, gene splicing, and other biotechnological applications.
8	Data Analysis Tools	While not strictly simulations, data analysis tools play a significant role in biology education. These tools allow students to work with real-world biological data and draw insights from experimental results.

Source: compiled by the authors.

It's essential to note that the specific software used in Ukrainian educational institutions varies. There is a need to invest in innovative specialized software to support biology education and research activities. However educational institutions cannot always do it.

The research made it possible to divide the above-mentioned simulation software according to usage by teachers of different educational levels in Ukraine (Figure 2).

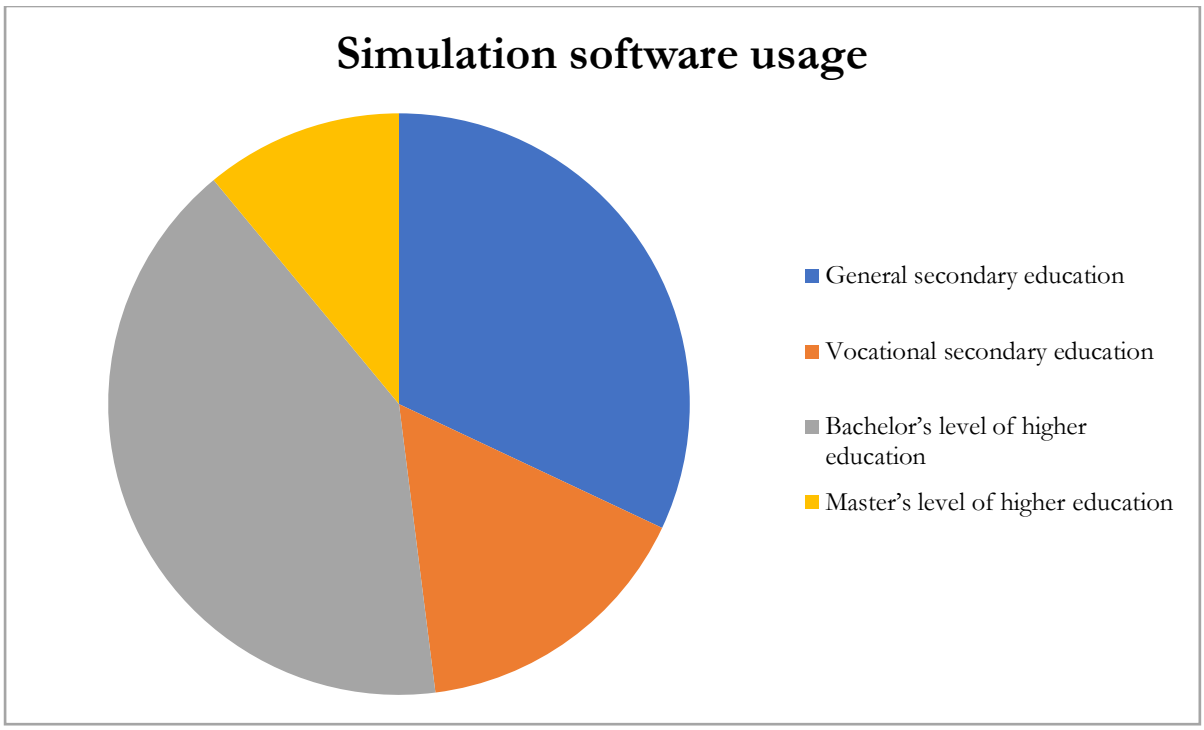

Figure 2. Division of simulation software according to usage by teachers of different educational levels in Ukraine.

The next step of our research was to determine the most effective mobile applications for learning biology. These apps are designed to provide students with interactive and engaging ways to learn biology concepts on their smartphones and tablets. They are given in Table 4.

Table 4. Mobile applications for Natural Sciences Teaching in Ukraine.

Mobile applications	Description of advantages
Biology Study Apps	These apps offer comprehensive biology study materials, including interactive lessons, quizzes, flashcards, and practice questions. They cover various topics in biology, such as cell biology, genetics, ecology, and evolution.
Anatomy and Physiology	These apps focus on human anatomy and physiology, allowing users to explore

Apps	the human body's structures and functions through interactive 3D models, quizzes, and reference materials.
Plant Identification Apps	Plant identification apps use image recognition technology to help users identify plants based on pictures taken with their mobile devices. These apps are useful for biology students studying botany and plant taxonomy.
Animal Identification Apps	Similar to plant identification apps, these apps assist users in identifying different animal species by analyzing pictures taken with their mobile devices. They are beneficial for biology students studying zoology and wildlife biology.
Virtual Dissection Apps	Virtual dissection apps provide a digital alternative to traditional dissection, allowing students to explore and learn about anatomical structures without the need for physical specimens.
Ecology and Environmental Apps	These apps focus on ecological concepts and environmental issues. They often include interactive simulations, case studies, and data visualizations to enhance students' understanding of ecological processes.
Science Communication Apps	Some apps focus on science communication and deliver biology-related news, research articles, and discoveries to keep students updated with the latest developments in the field.
Biotechnology and Genetic Engineering Apps	These apps cover topics related to biotechnology, genetic engineering, and molecular biology, offering interactive modules and simulations to understand advanced biological concepts.

Source: compiled by the authors.

Given the fact that today most educational institutions of Ukraine work remotely or in a mixed format, the use of online collaborative platforms for learning biology has become relevant. Online collaborative platforms play a crucial role in facilitating real-time communication, group work, and knowledge sharing among biology students and educators. These platforms provide opportunities for collaboration beyond the traditional classroom setting, allowing students to engage with the subject matter in a more interactive and interconnected manner. Here are the most popular and used online collaborative platforms that can be used for learning biology.

Google Workspace for Education (formerly G Suite for Education) offers a suite of tools, including Google Docs, Google Sheets, Google Slides, and Google Drive, that allow students and teachers to collaborate on documents, presentations, and spreadsheets in real time. They can work together on biology-related projects, share research findings, and provide feedback on each other's work.

Microsoft 365 Education provides similar collaborative tools like Microsoft Word, Microsoft Excel, and Microsoft PowerPoint, which enable students and educators to collaborate seamlessly on biology assignments and projects. Microsoft Teams, an integral part of Microsoft 365, also facilitates communication and teamwork among students.

Moodle is another widely used open-source LMS that supports collaborative features. It allows educators to create biology courses with interactive quizzes, forums, and collaborative activities to engage students in a virtual learning environment.

Edmodo is an education-focused social networking platform that facilitates communication and collaboration among students and educators. It allows biology teachers to create a virtual classroom, share resources, and host discussions (worked till 22.08.2022).

Padlet is an online collaborative tool that serves as a virtual bulletin board. It allows students and educators to post text, images, videos, and links related to biology topics, fostering collaboration and knowledge sharing.

Flipgrid is a video-based discussion platform where students and educators can engage in video discussions on biology-related topics. It promotes a more interactive and personal learning experience.

Slack is a popular team communication platform that enables students and educators to create channels for different biology topics, discussions, and projects. It allows for real-time messaging, file sharing, and integration with other tools, making it suitable for collaborative biology learning.

Canvas is a learning management system (LMS) that supports collaborative features, including discussion boards, group assignments, and peer reviews. Instructors can create biology courses, share resources, and foster interactive discussions among students.

Trello is a visual project management tool that can be used for collaborative biology projects. Students and educators can create boards, lists, and cards to organize tasks and progress.

These online collaborative platforms provide a range of features to support biology learning, allowing students to interact, share ideas, and collaborate on various projects and assignments. The choice of platform depends on the specific needs and preferences of educators and students in the context of their biology courses.

The survey of biology teachers using online collaborative platforms in the educational process made it possible to determine the percentage of every platform usage at different levels of education (table 5).

Table 5. Division of Online Collaborative Platforms Usage for Biology Teaching in Educational Institutions of Different Levels.

	General secondary education	**Vocational secondary education**	**Bachelor's level of higher education**	**Master's level of higher education**
Google Workspace for Education	42 %	34 %	28 %	29 %
Microsoft 365 Education	18%	19%	13%	12%
Moodle	2 %	15 %	44 %	45 %
Flipgrid	12 %	12 %	4 %	3 %
Padlet	22 %	16 %	6 %	5 %
Canvas, Trello, Edmodo, Slack	4 %	4 %	5 %	6 %

According to the results of the research, we can conclude that Google Workspace for Education is the most used one among all the other platforms. At the same time general secondary education institutions (as a rule schools of different types) most use it. The percentage ratio of the use of various online platforms by secondary education institutions can be seen in the Figure.

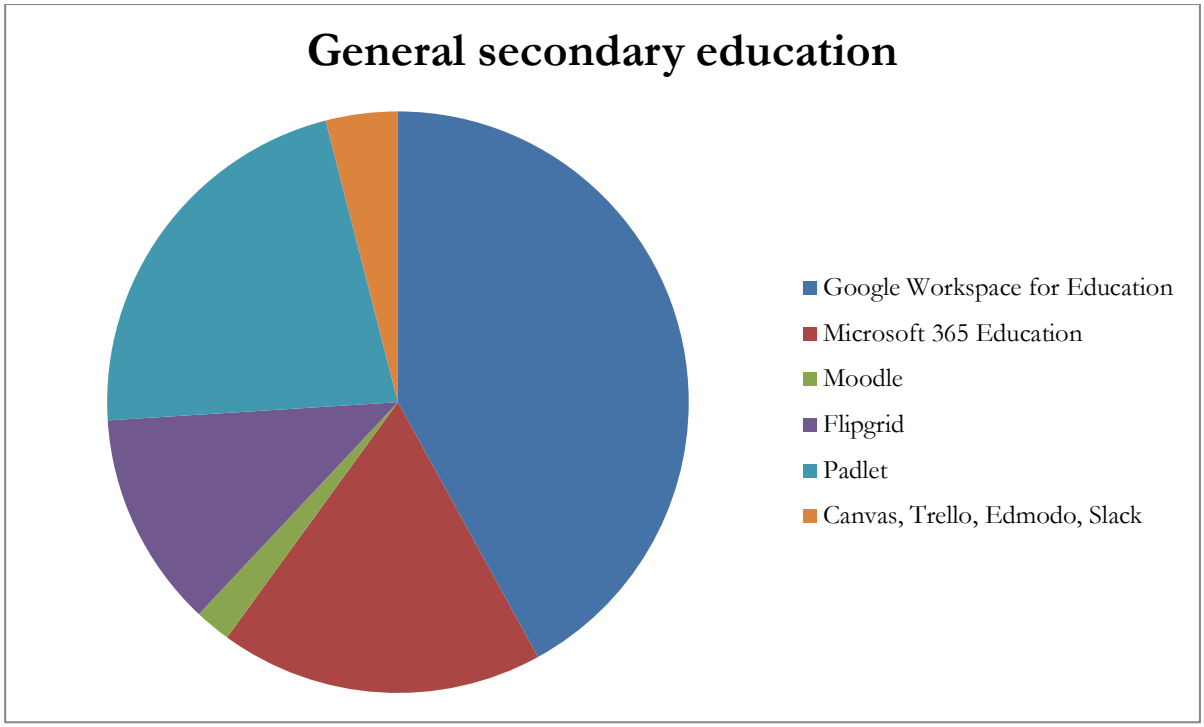

Figure 3. The percentage ratio of the use of various online platforms by secondary education institutions in Ukraine.

Thus, the analysis of a survey of biology teachers in Ukraine with different teaching experiences in general secondary education has shown the need to use innovative technologies for teaching natural sciences. One way to solve this problem is to invent new formats of implementing modern technologies, in particular, based on the principles of STEM education and open education.

Vocational secondary education institutions and higher education establishments have another percentage ratio of online platform usage, given in Figure 4 and 5.

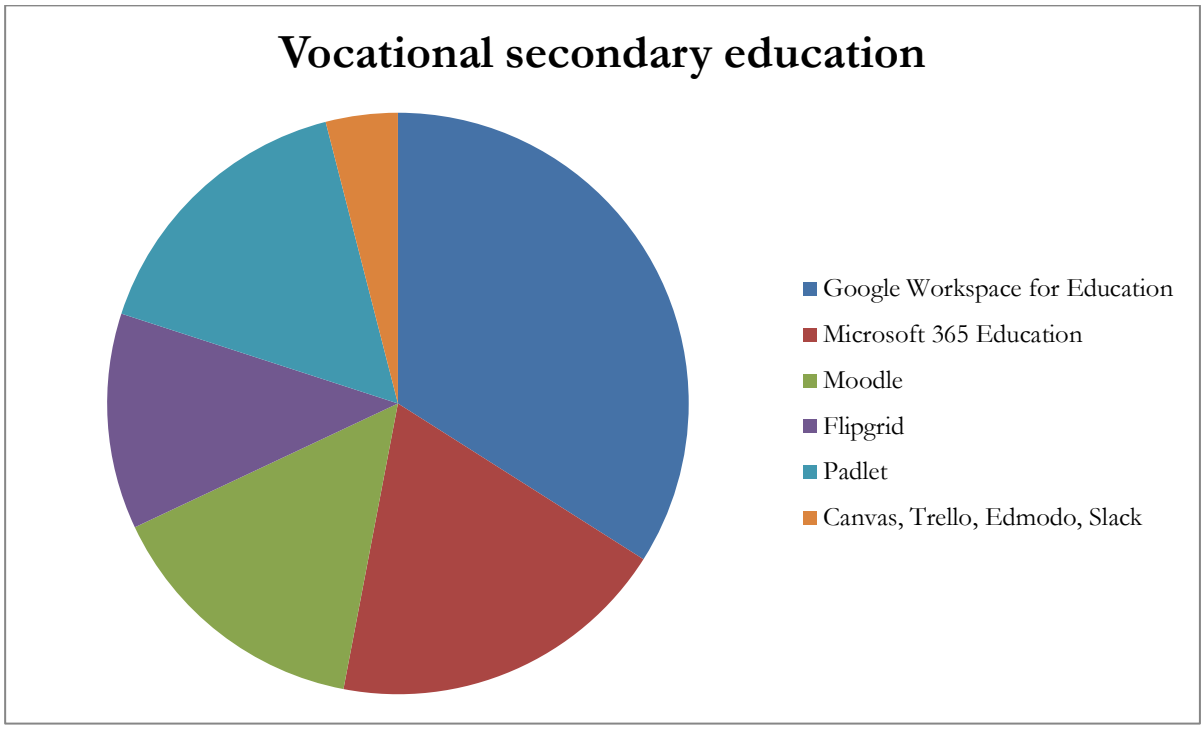

Figure 4. The percentage ratio of the use of various online platforms by vocational secondary education institutions in Ukraine.

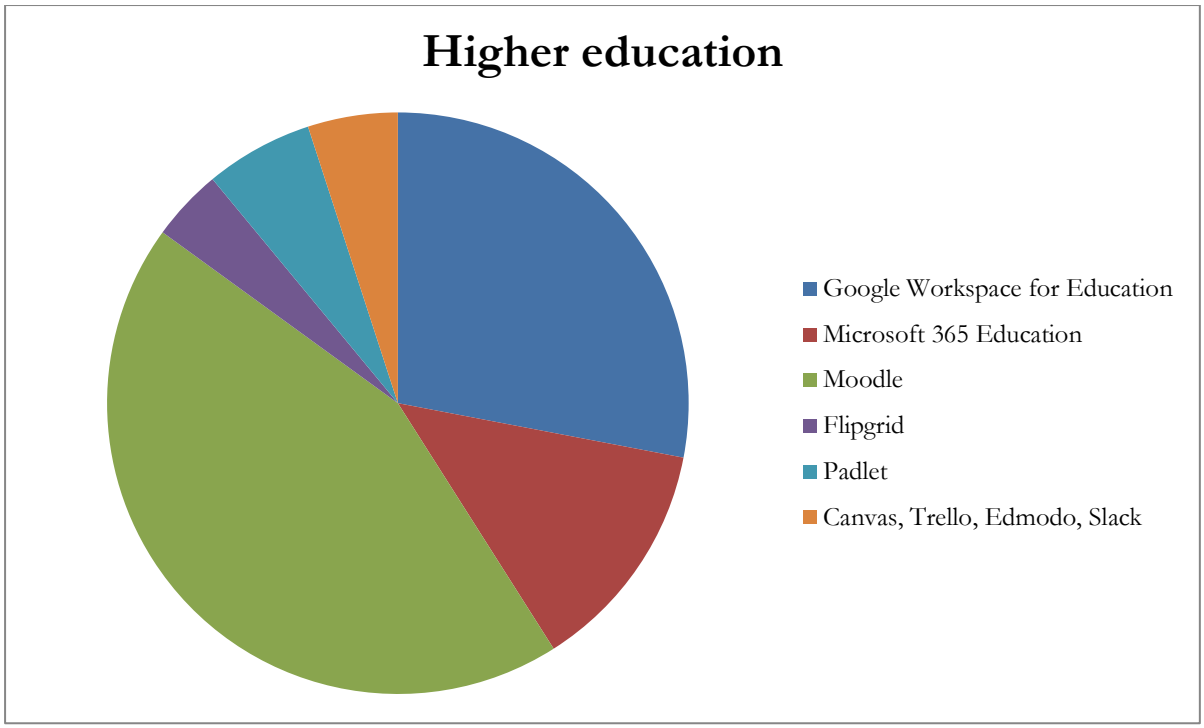

Figure 5. The percentage ratio of the use of various online platforms by higher education institutions in Ukraine.

It's important to note that many academics are embracing innovative technologies as a valuable means of teaching biology. Over time, their benefits become more apparent and teachers' attitudes evolve. Therefore, our research deals with new findings regarding innovative technologies usage, and it aimed to examine the effects of modern technologies on teaching natural sciences. The issue of using innovative technologies, in particular distance, became especially important after the start of the 2019 coronavirus pandemic. The works of S. Rudyshyn et al. (2022); J. Grund & A. Brock (2020); I. Molderez, & E. Fonseca, (2018); E. Hartadiyati et al. (2020) revealed that incorporating innovative technologies in education has a positive impact on teaching biology at education institutes. Our research confirms the previous results (M. Sidorovich et al., 2022) and proves that innovative technology implementing has both positive and negative impacts on educational processes, and a balanced approach is recommended for a productive educational process. Moreover, the study is in good agreement with Sebastian-Lopez, M., & de Miguel Gonzalez, R. (2020) the evidence we found points to the main directions of innovative learning for sustainable development and environmental teacher education in Ukraine.

CONCLUSION

Our work has led us to conclude about the importance of using innovative educational technologies for developing the level of Natural sciences competence at education institutions in Ukraine. On the basis of scientific literature we have determined the most effective innovative educational technologies for teaching biology: virtual reality (VR) and augmented reality (AR), simulation software, online laboratories, gamification, interactive whiteboards and smartboards, online collaborative platforms, mobile apps, personalized learning platforms, data analysis tools, biotechnology kits for using at different educational levels. The results of teachers' survey made it possible to state that in contemporary conditions in Ukraine, it is not possible to use all the mentioned innovative technologies. Only 3 or less innovative technologies are used in each educational institution.

At the result of next stage of the research, teachers of different educational levels in Ukraine rated the means of simulation software according to usage. We concluded that the teachers of general secondary education and of Bachelor's level of higher education the most often use simulation software technologies. Then we have determined the most effective mobile applications for learning biology: biology study apps, anatomy and physiology apps, plant identification apps, animal identification apps,

virtual dissection apps, ecology and environmental apps, science communication apps, biotechnology and genetic engineering apps.

The survey of biology teachers made it possible to study the current state of online collaborative platforms using for learning biology at different levels of education in educational institutions of Ukraine. According to the results, we can resolve that Google Workspace for Education is the most used one among all the other platforms. At the same time schools of different types most use it.

In conclusion, in the paper, we have presented the study of the peculiarities of innovative educational technologies usage in the process of teaching Natural sciences at education institutions. The research proved the effectiveness of innovative educational technologies usage for teaching Natural sciences at education institutions in Ukraine.

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