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## Use of digital technologies for innovation in teaching: Comparison of international and domestic approaches

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### Abstract

**Relevance.** The research article is relevant as it compares international and Ukrainian approaches to using digital technologies in education, aiming to identify common features, differences, and areas for further development in enhancing teaching and learning through technology.

**Purpose.** The study aims to compare and analyse international and Ukrainian approaches, in Ukraine and France, to the use of digital technologies in teaching to identify common and distinctive features and determine directions for further development in this area.

**Methodology.** The study conducted a survey of teachers of higher education institutions in Ukraine, at the European University, Zhytomyr Ivan Franko State University, Dragomanov Ukrainian State University and Taras Shevchenko National University of Kyiv, and a comparative analysis of approaches to the use of digital technologies in education in the educational space of Ukraine and France.

**Results.** This research has shown that the use of digital technologies in education contributes to the creation of a dynamic and effective learning environment. The comparative analysis of the use of digital technologies in teaching mathematics and computer science in Ukraine and France shows that both countries use interactive whiteboards, online resources and individualised approaches to learning, which indicates a general interest in the use of modern technologies in education.

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However, Ukraine faces challenges related to the limited availability and development of digital infrastructure, as well as limited financial resources for the introduction of digital technologies in the educational process compared to France.

**Conclusions.** Ukraine and France are actively working to innovate and develop modern approaches to education, which creates a positive outlook for the future use of digital technologies in educational institutions.

**Keywords:** digital technologies; innovations; virtual reality; gamification; learning effectiveness; multimedia materials; online platforms.

## Introduction

Digital technologies are transforming modern education, making it more accessible, efficient and engaging for students and teachers. Thanks to the Internet and digital resources, education is becoming more accessible, providing a wealth of learning materials. The use of interactive digital tools increases the interest of students and promotes better learning. In addition, digital platforms allow for the creation of individual learning paths for each student, considering their needs and level of knowledge. Education also needs to prepare students for a future where digital technologies will become an important element, so using these technologies in learning helps to develop the skills needed to succeed in the modern world. In addition, digital technologies are opening opportunities for global collaboration, enabling learners and teachers to collaborate with colleagues from around the world and share knowledge and experience. In general, digital technologies are changing the approach to education, making it more innovative and adapted to modern requirements.

Different countries use digital technologies in teaching according to their unique needs and capabilities. International approaches can include best practices from other countries in the use of digital technologies in teaching. The study of international approaches identified effective technologies and methods that can be adapted to local conditions, which helps to optimise the use of resources in domestic educational programmes. Exploring different approaches to the use of digital technologies helps to identify best practices and methods that can contribute to improving the quality of education and student outcomes. The education sector is constantly changing, and digital technologies are playing a key role in these changes. Studying international and Ukrainian approaches helps to adapt to these changes.

The problem of the study is the difficulty of identifying the differences and common links between international and domestic approaches to the use of digital technologies in the educational process. The rapid pace of technological development can lead to different levels of accessibility and adoption of digital technologies across countries, creating difficulties in comparing approaches and identifying commonalities due to rapid changes in technology.

Many researchers addressed the use of digital tools in education. The study by L. Hrynevych et al. [1] emphasises the importance of teachers' and future teachers' interest in using digital tools they point out the significant interest of target groups in mastering digital skills. In turn, R. Gurevych et al. [2] considered the advantages of using tools that allow updating curricula following modern knowledge and technologies. Further research should evaluate the impact of digital education systems on the quality of learning and student learning, which will help

determine which components of these systems are most effective and contribute to successful learning.

The use of modern technologies, such as virtual reality (VR), augmented reality (AR) and mixed reality (MR), is an important aspect of the study. M. Pears et al. [3] emphasised the importance of using immersive technologies, including VR, AR and MR, in education. R. Salar et al. [4] highlighted the potential of these technologies to create unique learning experiences that enable learning anywhere and anytime. G. Ryan et al. [5] emphasised that immersive technologies could help create adaptive learning environments but note that students' emotional investment and presence in AR can affect their focus. However, there are still some aspects that require further study in this area. The impact of these technologies on the social and psychological development of students and their interaction with the environment should be studied. Such research will determine the potential of immersive learning technologies and develop optimal approaches to their use to achieve the best results.

Many scholars have studied the use of computer games in education. The results of a study by Z. Sabirli and A. Çoklar [6] point to the spread of the use of these games among children due to their various functions, from multimedia capabilities to stimulating motivation to learn. The pedagogical approaches developed by M. Videnovik et al. [7] open new perspectives for improving the quality of education and creating interest of students in the learning process. According to N. Behnamnia et al. [8], the use of computer games stimulates educational goal achievement and can contribute to the development of creative and critical skills, digital experience and positive attitudes towards learning. However, certain aspects still need to be further explored in this study. It is important to consider which computer game-based learning methodologies have the greatest potential to provide profound learning for students. Such a study would help to better understand the role of computer games in learning and determine the best strategies for using them to achieve maximum pedagogical results.

The study aims to conduct a comparative analysis of Ukrainian and French approaches to the use of digital technologies in education.

## Materials and Methods

This research analyses the use of digital technologies in the process of teaching computer science and mathematics in both the French and Ukrainian educational systems. The study examined the specific features of the impact of digital tools on the creation of a learning environment that actively mobilises students to engage in the learning process. The analysis identified key aspects of individualised learning, interactive methods, gamification and the use of multimedia that affect the effectiveness of learning and the interest of students in the process. The

study also summarised specific aspects of using online platforms to make learning more accessible and flexible for students, by creating opportunities for individual pace of learning and communication with like-minded people in the learning process.

The study was based on the Order of the Ministry of Education and Science of Ukraine No. 776 “On Approval of the Concept of Teacher Education Development” [9], which defines the main directions of development of teacher education in Ukraine and sets strategic goals in the field of improving the quality of education and teacher training, as well as Order of the Ministry of Education and Science of Ukraine “On Instructional and Methodological Recommendations for Teaching Academic Subjects/Integrated Courses in General Secondary Education Institutions in the Academic Year 2023/2024” [10], which contains instructional and methodological recommendations for organising the educational process in Ukrainian general secondary education institutions. The work was also based on the strategic recommendations of the Ministry of National Education and Research of France, which defines the strategic directions of education development in France and contains recommendations on the use of digital technologies in the educational process [11].

The initial stage of this research was a survey. The study was conducted based on several universities in Ukraine engaged in teacher training and retraining (European University, Dragomanov Ukrainian State University and Taras Shevchenko National University of Kyiv, Zhytomyr Ivan Franko State University) and lyceums in Zhytomyr, where teachers and teachers were interviewed. The study lasted from 06.05.24 to 14.05.24 to collect empirical data. The total number of respondents was 100 people aged 26 to 65, including both men (aged 26 to 65) and women (aged 26 to 58). The main purpose of the survey was to study the respondents’ views on the use of digital tools in the modern educational process. The questionnaire was designed to identify the main factors

influencing the perception and use of digital technologies for teaching innovations among teachers of higher and general secondary education institutions in Ukraine.

The survey questionnaire was designed in the format of closed questions, where participants had to choose one of two alternative answers – “Yes” or “No”, depending on their attitude to specific aspects of the use of digital technologies in teaching. The questions covered a wide range of topics aimed at determining the participants’ views on the use of digital tools for innovation in the educational process, their experience of using such technologies and their perception of their impact on the education system.

## Results

Digital technologies for teaching innovation are a set of tools and resources based on advanced digital developments. These technologies cover a wide range of tools, from interactive whiteboards and online platforms to mobile applications and VR. One of the key aspects of their use is the creation of a dynamic and effective learning environment that promotes the active involvement of students in the learning process. The use of digital technologies allows teachers to individualise the learning process, considering the needs and interests of each student. This facilitates access to educational material and creates new opportunities for interaction between teachers and students. Interactivity, gamification and other methods stimulate the interest of students and promote their motivation to learn. Overall, digital technologies for teaching innovation are changing the paradigm of learning, making it more engaging, accessible and effective. This improves the academic performance of students and creates conditions for their continuous development and learning. Modern education uses a variety of digital technologies to improve the teaching and learning process (Figure 1).

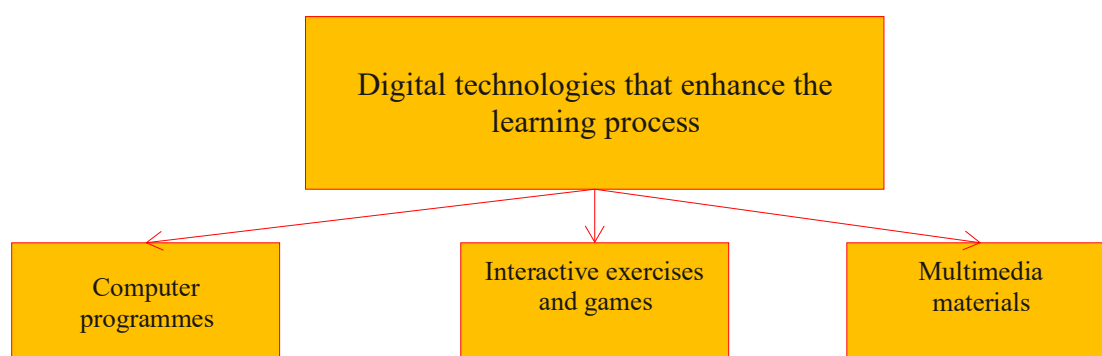


Figure 1. Digital technologies that enhance the learning process

Source: compiled by the authors.

Digital technologies make learning more efficient, accessible and engaging, contributing to the quality of education. The use of specialised software can facilitate the process of learning and solving complex mathematical problems. For instance, MATLAB [12] or Mathematica [13] can be used to perform calculations, analyse data, solve equations, and model complex mathematical

processes. They can also be used to create graphs and visualisations to better understand the results. As for web-based applications for learning programming, such as Codecademy [14] or Khan Academy [15], they allow students to learn basic programming principles, and programming languages and create their own programs, working in an online environment without the need to

install additional software on the computer. These resources also often include interactive exercises, tests, and projects to help students consolidate their programming knowledge and skills. In general, the use of such software and web applications in education allows students to acquire practical skills and learn in an interactive, convenient environment, which contributes to improving the quality of education in mathematics and programming. In both Ukraine and France, the use of specialised software and web applications in teaching mathematics and programming contributes to improving the quality of education and developing students' practical skills. In Ukraine, for example, MATLAB or Mathematica software can be used to perform calculations, analyse data and model complex mathematical processes. This creates opportunities for students to better understand the material and gain practical experience in solving problems. In France, web-based applications such as Codecademy or Khan Academy are also widely used, enabling students to learn the basic principles of programming and create their applications in an online environment. These resources also include interactive exercises, tests, and projects to help reinforce programming knowledge and skills. In both cases, the use of these tools allows students to gain practical skills and learn in an interactive, user-friendly environment, which contributes to improving the quality of mathematics and programming education.

The creation and use of multimedia materials in education is an important component of the modern educational process. Video presentations, audio lectures, animations, interactive simulations, and virtual laboratories help students better understand and remember complex concepts and facilitate understanding and application of the material [16]. For example, video presentations can include images and explanations of key concepts, charts and graphs to illustrate concepts, audio lectures allow students to listen to material in the form of audio recordings for better absorption of information, and animations can reproduce processes and phenomena in real-time to better understand how they work. Interactive simulations and virtual laboratories allow students to experiment and interact with material in a virtual environment, which increases their engagement and active learning. These tools can also help recreate real-life situations and solve problems, which helps students gain practical experience and skills. In general, multimedia materials provide a more dynamic and effective learning experience, contributing to better understanding and retention of the material, as well as stimulating the active participation of students in the learning process.

The use of online learning platforms such as Coursera [17], Udemy [18], edX [19] and others is becoming an increasingly popular method of learning mathematics and computer science. These platforms can be used by students to register for courses of their choice and start studying the material at a time and pace that suits them. One of the advantages of these platforms is the availability of a wide variety of courses in various fields of mathematics and computer science. Students can choose courses according to their interests, level of knowledge and skills. In addition, many of these courses are offered free of charge or for an affordable fee, making them accessible to a wide range of users. Online platforms also provide learners with the

opportunity to study at the desired pace. Students can watch video lectures, read texts, and complete exercises and assignments at any time convenient for them, without being limited by the schedule of traditional classes. This is especially useful for students with different levels of training and different work schedules. In addition, on online platforms, students can interact with teachers and other students through discussion forums, chats, and other online communication tools. This can be used to share thoughts, ask questions and discuss complex topics, promoting active learning and mutual knowledge growth. In general, the use of online platforms for teaching mathematics and computer science opens new opportunities for students, providing access to quality educational material, flexible schedules and the opportunity to interact with a community of experts in the relevant field.

Creating video lessons for teaching opens many opportunities for effective learning [20]. These videos allow learners to watch lessons at any time convenient for them, and to return to difficult concepts or tasks for deeper understanding. With video tutorials, teachers can explain complex mathematics and computer science concepts in an accessible way. They can demonstrate the solution to various problems, providing students with examples and illustrations, which contributes to a better understanding of the material. In addition, video tutorials can contain animations and visualisations that help learners grasp abstract concepts by visualising them. An important advantage of video tutorials is their flexibility. Learners can watch lessons at any time from a convenient location, allowing them to study at home, at school, or even while travelling. This is especially useful for learners with different work schedules and commitments. In general, creating video lessons for teaching mathematics and computer science is a powerful tool that helps students learn complex concepts and solve problems more efficiently, thanks to its accessibility, flexibility and high-quality explanation of the material.

Methods of learning through computer games can be varied and include approaches such as game simulations, game tasks, team games, interactive learning and gamification. The use of game simulations allows for the creation of virtual environments in which learners can experiment, solve problems and learn in a safe and controlled environment, which can be particularly useful for learning in fields where hands-on experience is important, such as medicine, engineering or business management. The use of game-based tasks allows students to learn by solving specific tasks or problems in the form of a game, which may include logic puzzles, quests, simulations of real-life situations. The use of collective games promotes cooperation and communication among game participants. They can include team tasks in which students have to work together to achieve a common goal. Computer games can be used to create interactive learning experiences where learners can interact with the material, exploring it at the desired pace and according to personal interests. These techniques can be effective in engaging students and creating a stimulating learning environment. However, it is important to be attentive to the individual needs and characteristics of each student, as well as to ensure a balance between entertainment and learning.

The use of interactive exercises and games in the learning process is an important element in engaging students and creating an environment that stimulates active learning [21]. These tools allow students not only to gain knowledge but also to apply it in practical situations, develop critical thinking and draw personal conclusions. Interactive exercises and games allow students to experiment with different concepts, try different approaches and develop their strategies. For example, they can use interactive simulations to learn complex mathematical or software concepts where they can change parameters and observe the results. This allows students to “touch” and see the impact of their actions on the result. In addition, interactive exercises and games can be specially designed to increase student motivation and create a competitive atmosphere. For example, the use of group games or online competitions can stimulate a competitive spirit and encourage more active participation in the learning process.

Thus, the use of interactive exercises and games is an important element of modern learning, as they promote the active involvement of students, and develop their skills and motivation to learn. In Ukrainian schools, teachers actively use interactive exercises and games to teach, allowing students to gain knowledge and apply it in practical situations. Interactive exercises help students experiment with concepts and develop critical thinking, which promotes active learning. In France, interactive exercises and games are also popular in the educational process. They encourage students to actively participate and develop their skills, and they foster a competitive atmosphere that increases motivation to learn.

The introduction of gamification in education opens great opportunities to stimulate the activity and motivation of students. Teachers can create virtual classrooms or game worlds where students can interact with learning material. This may include the use of special online platforms or mobile applications that can be used to create interactive tasks and challenges. Teachers can use a system of achievements or badges that reward students for achieving specific goals or completing tasks. This encourages students to actively participate and achieve success in their studies. Teachers can organise regular gaming activities such as knowledge competitions, thematic quizzes or online problem-solving tournaments. This not only promotes active learning but also strengthens the classroom community and fosters positive competition among students. Teachers can incorporate game elements into learning tasks, such as quests, puzzles, or interactive simulations. This helps to make the learning process more interesting for students. In Ukrainian schools, teachers are actively introducing digital technologies into the educational process to improve the quality of learning and create favourable conditions for students’ development. Some of the innovative approaches and methodologies being implemented in Ukrainian education with the help of digital technologies include interactivity in learning, gaming elements, individualised learning, the use of VR, online learning and open educational resources.

Teachers are using interactive whiteboards, collaboration software, and online platforms to engage students in the classroom and make learning more interesting and effective [22]. Interactivity can be used to

create dynamic lessons with the active participation of students. To maximise the effect of using interactive technologies in the learning process, teachers can also use other innovative methods of creating interactive tasks and games, where teachers can develop interactive tasks and games that promote active interaction of students with the learning material. For instance, interactive exercises for solving maths problems or virtual laboratories for science experiments. Interactive technologies can stimulate collaboration and communication between students through joint problem-solving or project activities. Teachers can organise group projects using collaboration apps and online platforms to share ideas and resources. Interactive technologies can help teachers assess the level of learning of students through tests, quizzes and other interactive tools. Teachers can use online platforms to conduct tests and analyse the results. Teachers can encourage students to create their projects, video presentations or audio recordings using interactive technologies. This allows students to develop creative skills and originally express their ideas and thoughts.

Individualised learning, enhanced by digital technology, is truly transforming the way teachers deliver education. Teachers can use digital platforms to create individualised curricula for each student, considering their needs, level of knowledge and personal interests. For example, they can set individual goals for each student and develop personalised tasks to achieve these goals. Digital platforms can adapt learning material according to the level of understanding and progress of each learner. For example, apps can automatically adjust the level of difficulty of tasks or provide additional explanations if a learner has difficulty understanding a particular topic [23].

Learners can be able to study material at their own pace and at a time convenient for them using digital resources. This allows them to manage their time more efficiently and feel more responsible for their learning. Digital technologies can also facilitate parental involvement in the learning process by providing access to information about their child’s progress and the ability to communicate with teachers through online platforms or apps. Special digital tools can also be developed to support clubs and extracurricular activities. Ukrainian teachers can use digital platforms to create individualised curricula for each student according to their needs, level of knowledge and interests. This allows for a more effective learning environment where each student can develop according to their individual needs. In France, there is also a significant potential for digital technologies to individualise learning. Teachers can use digital platforms to create personalised curricula and adapt learning material to the needs of each student. In both countries, digital technologies allow learners to study at the desired pace and at personal convenience, which contributes to more effective learning. In addition, they promote parental involvement in the learning process and develop a partnership between school and family.

The introduction of VR [24], AR [25], and MR [26] into Ukrainian schools and universities opens new opportunities for immersive learning and research. The use of VR and AR can be used to create interactive lessons where students can interact with virtual objects and environments. For instance, they can study architectural

and historical monuments, solve mathematical problems in three-dimensional space, or learn biology by interacting with virtual organisms. VR, AR, and MR can be used to organise virtual tours to places that are inaccessible for a physical visit, as well as create virtual laboratories for studying scientific disciplines. It can be especially useful for studying geography, astronomy, chemistry and physics. VR, AR, and MR can be used to create simulations and trainers for hands-on training in various fields, from medicine to engineering. For example, medical students can study anatomy and treatment procedures in a virtual environment, and engineers can interact with virtual machines and mechanisms. VR, AR, and MR can be used to organise collaborative learning and collaboration, where students can work together in a virtual space, even if they are in different locations. The use of VR and AR fosters creativity and innovation, as they allow for new, unique learning experiences and experimentation with different approaches to learning.

The use of VR, AR and MR technologies can stimulate the development of empathy and social skills. For instance, in a virtual environment, students can see into the skin of another person, which helps them better understand the thoughts and feelings of others. The use of shared virtual environments for communication and collaboration can increase the level of interpersonal interaction among students. This can happen through collaborative work on projects or interactive games, where communication and cooperation become key elements of success. The use of AR and MR technologies can increase opportunities for visual and auditory communication, which contributes to the development of students' communication skills. students can learn to interact effectively with each other, as well as with teachers and other professionals in a virtual environment. Using VR for simulated learning scenarios can help develop teamwork, collaboration and conflict-resolution skills. students can learn these skills in a virtual environment, allowing them to experiment and improve them in a safe environment. For some students, the use of VR, AR and MR technologies can help boost their confidence. For example, through virtual simulations, they can learn new skills or test their knowledge in realistic conditions, which can have a positive impact on their belief in their abilities. To understand the full range of impact of these technologies on the social and psychological development of students and their interaction with the environment, additional research is needed to study the long-term effects of using VR, AR and MR technologies in education. It is also important to consider the individual differences of students and their unique needs to optimise the use of these technologies in the learning process.

The use of digital technologies in the educational process expands the opportunities for students to study at any time convenient for them and access a variety of educational resources. students can register for online courses in various subjects on the platforms. They can learn at their own pace and at any time that suits them by watching video tutorials and completing assignments. students can use e-textbooks and other virtual resources to learn at their own pace. This can include interactive textbooks, video lectures, audio materials and other online resources. students can benefit from a variety of multimedia materials, such as audio and video tutorials,

interactive animations and simulations, to help them better absorb material and understand complex concepts. Through the Internet, students can access a wide range of educational resources, such as scientific articles, open courses, webinars, libraries and databases. Digital technologies allow students to study new material or deepen their knowledge in a particular field independently, without being limited by class schedules or location. They can use various applications and online resources for self-education and development. Teaching computer science with the use of digital technologies has its specifics, as computer science is a field that provides many opportunities for interaction with digital tools and platforms. Teachers may use specialised software products such as development environments (e.g. Visual Studio [27] for C++, Java or C#), database management systems (e.g. MySQL [28] or PostgreSQL [29]), modelling environments (e.g. MATLAB [30] for signal processing or Simulink [31] for system modelling). This allows students to gain practical experience in using real-world tools that they can apply in their future professional activities.

Modern learning platforms such as Codecademy [32], Udacity [33], and others provide students with the opportunity to learn various aspects of programming and other areas of computer science in the form of interactive courses and projects. This promotes active learning and allows students to gain hands-on experience in real virtual environments. With the help of virtual laboratories and interactive simulations, students can experiment with various concepts and technologies without real equipment. This allows students to learn complex concepts by conducting experiments and solving problems in a virtual environment. Digital technologies enable students to develop practical skills by participating in project work and solving real-world problems using programming and other computer science tools. Thus, the use of digital technologies in teaching computer science allows students to gain practical experience and develop skills that are important for their future careers in the field of information technology.

International approaches to teaching with digital technologies include a variety of methodologies and strategies used in educational practice in different countries that meet modern requirements and trends in education. Use of interactive learning methods, such as video lessons, interactive assignments and online courses, which allow students to actively engage in learning and access materials anytime, anywhere. Application of personalised learning approaches that address the individual needs, interests and learning level of each student. Using game elements to stimulate student motivation and engagement in learning, such as points, achievements and leaderboards. The use of immersive technologies to create meaningful learning environments that allow students to interact with learning materials in a virtual or augmented space. These approaches may vary from country to country and from institution to institution, but their goal is to provide effective and engaging learning using modern digital technologies.

In Ukraine, approaches to teaching with digital technologies also include a variety of methodologies and strategies specific to the Ukrainian educational system. Ukrainian schools and universities are actively using e-

textbooks and online learning resources to provide students with access to up-to-date and diverse information. The use of various electronic platforms, such as Google Classroom [34], to organise the learning process and communication between teachers and students. Using digital technology to create interactive lessons and exercises that help to engage students and make learning more fun. The use of online systems for conducting tests and assessing students'

knowledge, simplifies the assessment process and ensures the objectivity of the results. Promote the use of open educational resources and open access to educational materials to increase the accessibility and dissemination of knowledge. The study surveyed teachers about the use of digital technologies in the educational space (Table 1).

**Table 1.** Teacher survey results

Question	“Yes”	“No”
Do you use digital technologies in your teaching practice?	90%	10%
Do you think digital technologies are important for innovation in teaching?	98%	02%
Do you use international approaches to teaching with digital technologies?	45%	55%
Do you use approaches specific to the Ukrainian educational space to teach with digital technologies?	70%	30%
Do you think there are advantages of using international approaches compared to those inherent in the Ukrainian educational space to teaching with digital technologies?	60%	40%
Are you actively looking for opportunities to collaborate with teachers from other countries to share practices in the use of digital technologies in the educational process?	75%	25%
Do you think that the implementation of international approaches to teaching using digital technologies can help improve the quality of education?	57%	43%
Do you feel the need for further training in the use of digital technologies in teaching?	85%	15%

**Source:** compiled by the authors.

The survey results showed that a significant majority of teachers use digital technologies in their teaching practice, which indicates their confidence in the usefulness of these tools for the educational process. It is also evident that all respondents consider digital technologies to be a key element for innovation in teaching, which indicates a general awareness of their importance. Regarding the use of international and Ukrainian approaches to teaching with the use of digital technologies, it was found that a minority of teachers prefer international approaches. However, most respondents use domestic methods, which may reflect differences in cultural characteristics and approaches to education in different countries. It is important to note that a significant proportion of teachers believe that international approaches have advantages over domestic

ones, which may indicate a desire to use international best practices in teaching. It was also determined that most teachers are open to cooperating with colleagues from other countries to share their experience of using digital technologies. This demonstrates the willingness of teachers to improve their skills and use international best practices in teaching. All the surveyed teachers feel the need for further training in the use of digital technologies in teaching, which indicates their readiness for self-improvement and adaptation to the rapidly changing educational environment. The study’s comparative analysis of the use of digital technologies in teaching in Ukraine and France reflects both similarities and differences in approaches and achievements (Table 2).

**Table 2.** Comparative analysis of the use of digital technologies in teaching in Ukraine and France

Aspects	Ukraine	France
<b>Similarities</b>		
Use of interactive whiteboards and software	Ukrainian schools use interactive whiteboards and specialised software to improve the efficiency of the learning process. Teachers in Ukrainian schools are using interactive whiteboards to capture the attention of students and increase their participation in the classroom. These interactive whiteboards allow teachers to create dynamic lessons using a variety of multimedia materials, including video, audio, graphics and other interactive elements. In addition, specialised applications enable teachers to create interesting and	Teachers in French schools are actively using these technologies to attract the attention of students and create a stimulating learning environment. Interactive whiteboards allow teachers to create great lessons using a variety of multimedia resources and interactive activities. In addition, specialised programmes provide teachers with the opportunity to personalise learning material and create lessons that meet the needs of specific groups of students.

	interactive tasks that actively engage students in the learning process.	
Online resources and platforms for learning	Teachers in Ukraine are actively using various online resources and learning platforms, such as Moodle, Khan Academy, Coursera and others. These resources allow teachers to provide their students with access to additional materials, interactive courses, and learning activities. The use of such platforms helps to expand learning opportunities and helps teachers create interesting and varied lessons, considering the individual needs of students.	In France, teachers are also actively using online resources and learning platforms such as Moodle, Khan Academy, Coursera and others. These platforms provide teachers with the opportunity to engage students in learning through interactive tasks, online courses, and additional materials. The use of such resources helps teachers create a stimulating and developing learning environment, promoting the active involvement of students in the learning process.
Individualised training	Teachers in Ukraine use digital technologies to create individualised learning pathways for each student. They use different programmes and platforms that allow them to adapt the learning material to the needs of each student. This allows teachers to personalise the learning process, considering the individual characteristics and needs of students, which helps to increase the effectiveness of learning and increases the motivation of students.	In France, teachers also actively use digital technologies to create individualised learning paths for students. They use various applications and platforms that allow them to adapt the learning material to the needs of each student. This helps to engage students in the learning process, as they receive learning material that meets their individual needs and interests.
<b>Differences</b>		
Infrastructure and accessibility	In Ukrainian schools, teachers have less access to and development of digital infrastructure than in developed countries, which may limit the use of digital technologies in education.	In French schools, teachers have a more developed and accessible digital infrastructure, which contributes to the wider use of digital technologies in education.
Integration into the curriculum	The integration of digital technologies in the curriculum may be less than in other countries due to the lack of standardised approaches and the instability of educational reforms.	In schools in France, teachers have more standardised approaches to integrating digital technologies into the curriculum, as the country has a more stable educational system.
Funding and resources	Ukraine's education sector faces limited financial resources for the development and implementation of digital technologies in the educational process.	In French education, there are more financial resources and support for the development and implementation of digital technologies in the learning process.

**Source:** [35-37].

Based on the results of a comparative analysis of the use of digital technologies in teaching computer science and mathematics in Ukraine and France, the following conclusions can be drawn. Both countries use interactive whiteboards, online resources and platforms for learning, as well as individualised approaches to teaching, which indicates a general trend towards the use of modern technologies in education. However, Ukraine has limited accessibility and development of digital infrastructure, as well as limited financial resources for the introduction of digital technologies in the educational process compared to France, which has a more developed and accessible infrastructure and more financial resources. Consequently, Ukraine may face challenges related to limited resources and infrastructure, which may limit the ability to introduce digital technologies into the learning process compared to France. However, both countries are working together to innovate and develop modern approaches to education, which are positive signs for the future use of digital technologies in educational institutions.

In Ukraine and France, teachers are actively using digital technologies to improve the learning process and engage students. Interactive whiteboards and specialised software can be used to create interesting and stimulating

lessons, as well as provide an opportunity for interactive communication with the material, which facilitates the absorption of knowledge. In both countries, various online resources and learning platforms such as Moodle, Khan Academy, Coursera and others are popular. They help teachers provide students with access to additional materials and courses that complement the curriculum and make learning more interesting and effective. A special feature of digital technologies is the ability to create individualised learning paths for each student. They can be used to adapt the learning material to the individual needs and pace of learning of each student, which increases the effectiveness of learning and increases motivation to learn. However, there are certain differences between Ukraine and France in the field of digital education. For example, in Ukraine, the infrastructure and availability of digital technologies may be limited due to insufficient funding and the instability of educational reforms. In France, the infrastructure is usually more developed and accessible, and the integration of digital technologies into the curriculum can be more standardised due to the stability of the educational system and greater financial resources.

The further development of the use of digital technologies in Ukrainian education can be directed in



several directions. It is important to address the development of digital infrastructure and ensure access to it in all regions of Ukraine. This includes developing a fast Internet connection, providing broad access to computers and other digital devices, and training teachers to use digital technologies in the educational process. It is important to develop and implement programmes to train teachers to use digital technologies in teaching. This may include organising training, seminars and courses on digital competence for teachers, as well as creating pedagogical materials and resources for their training. It is also important to actively cooperate with international partners and use their experience in implementing digital technologies in the educational process. This may include the exchange of experience, participation in international projects and exchange programmes, as well as joint research and development of new digital learning resources. Given the war on the territory of the country, it is also important to ensure the safety and security of information in the digital environment and to provide support and assistance to teachers and schoolchildren who have experienced war and crises. In general, the development of digital technologies in education in Ukraine can be a significant factor in modernising and improving the education system, contributing to the training of a competent and competitive young generation.

## **Discussion**

The use of digital technologies in teaching creates a dynamic and effective learning environment that encourages students to be actively involved in learning. This helps to individualise the learning process, considering the needs and interests of each student. Interactivity, gamification and other methods stimulate interest in learning and increase motivation to learn. Multimedia materials, such as video presentations, audio lectures and virtual labs, make complex concepts easier to understand and provide opportunities for hands-on exploration. Online platforms make learning more flexible and accessible, allowing students to study at the desired pace and communicate with their peers. A comparative analysis of the use of digital technologies in the educational process in Ukraine and France shows that both countries use modern methods, although they may have differences in resources and infrastructure. However, it is important to analyse and compare different approaches to the use of digital technologies in education proposed by different scholars. By analysing different approaches to the use of digital technologies in education, it is possible to identify the advantages of each of them and determine the best way to further improve the educational process. Such a study will help to expand the understanding of the essence of digital tools in the learning environment and help to improve the methodology of their use to increase learning efficiency and achieve better results.

The results of this study confirm the importance of using digital technologies in teaching mathematics and computer science and their potential for innovation in these fields. The use of tools such as interactive whiteboards, online platforms, mobile applications, and VR creates a dynamic and effective learning environment that promotes the active involvement of students in the process of learning mathematics and computer science. This use of

technology allows teachers to individualise the learning process, considering the needs and interests of each student, thereby facilitating access to the material and creating new opportunities for interaction between teachers and students. In addition, interactivity, gamification, and other methods promote students' interest and motivation to study mathematics and computer science, which helps to improve their academic performance and creates conditions for continuous development and learning. In comparison with the results of the study by J. Ramos et al. [38] the significant role of information and communication technologies, including video technologies, in the digital transformation of education is determined. Information and communication technologies have become an integral part of education and training in many countries around the world, which confirms their importance in improving the quality of education and developing the modern educational system.

The results of this study confirm that the use of interactive exercises and games in the process of teaching mathematics and computer science plays an important role in attracting the attention of students and creating a stimulating learning environment. These interactive methods allow students not only to learn theoretical knowledge but also to apply it in practice, developing critical thinking and the ability to analyse it independently. According to a study by S. Vanbecelaere et al. [39], digital learning games with integrated adaptability have proven to be promising for training academic skills. These games, according to various studies, are more effective for teaching mathematics and computer science than non-adaptive games, as they adapt the complexity of tasks to the individual level of each student. This approach can be used to address the needs and abilities of each student, which helps to improve the learning process. Thus, the use of interactive exercises and games in teaching is an important element in creating a learning environment that promotes the active engagement of students and the development of their skills. This approach to learning makes it possible to effectively use modern digital technologies to achieve learning objectives.

The results of this study indicate a significant potential for using VR and AR in teaching mathematics and computer science. The introduction of such technologies opens new opportunities for immersive learning and research, allowing for interactive lessons and virtual tours to inaccessible places. The use of VR and AR can also be used to organise virtual laboratories for studying scientific disciplines and create simulations for practical training in various fields. According to the research of D. Hamilton et al. [40], high-precision graphics and engaging content using overhead displays allow students to explore complex subjects that are not possible with traditional teaching methods. M. Kuhail et al. [41] note that immersive technologies significantly improve learning by simplifying and simulating complex concepts in various fields. Thus, the use of VR and AR in educational institutions can be an effective tool for creating innovative learning environments that promote the active engagement of students and the development of their skills and creativity.

The study confirms that the use of digital technologies in computer science education is extremely important and effective. students are allowed to learn programming and

other aspects of computer science using specialised software products such as Visual Studio for C++, Java or C# programming languages, or database management systems such as MySQL or PostgreSQL. This allows them to gain practical experience with real tools that are important for their future professional activities. N. Horri and M. Pietraszko [42] emphasise that MATLAB and Simulink can be used to teach in a realistic three-dimensional virtual environment. This provides students with the opportunity to learn and experiment in an interactive environment, which helps them to better absorb the material. In addition, the use of modern learning platforms such as Codecademy and Udacity allows students to learn various aspects of programming and computer science through interactive courses and projects. This active learning allows students to gain hands-on experience in virtual environments and develop their skills. B. Klimek and M. Skublewska-Paszkowska [43] confirm that MySQL is an effective programming software, while K. Milad [44] notes that learning to program is one of the key aspects of a computer course, and tools such as Codecademy help students learn. Thus, these results emphasise the importance of using digital technologies in computer science education and their potential to improve students' learning and development.

The results of this study highlight the importance of digital technologies in modern education and their potential for innovation in teaching. The use of interactive technologies, such as interactive whiteboards, online platforms and VR, contributes to the creation of a dynamic and effective learning environment that actively engages students in the learning process. Individualisation of learning, gamification and other innovative methods stimulate the interest and motivation of students, which helps to improve their learning experience and academic performance. The study also points to the importance of using interactive exercises and games to create a learning environment that promotes active student engagement and skill development. The introduction of VR and AR into the educational process opens new opportunities for immersive learning and research, which helps to enrich students' learning experiences and develop their creativity. In addition, the use of modern learning platforms and software tools, such as Codecademy and MATLAB, allows students to gain practical experience in virtual environments and develop their skills in various fields, which is important for their future professional careers. Thus, the use of digital technologies in the educational process is an important step towards modern and effective education that meets the requirements of the modern world.

## Conclusions

The use of digital technologies allows the creation of a dynamic and effective learning environment that promotes the active involvement of students in learning. An important aspect is the individualisation of the learning process, which allows teachers to consider the needs and interests of each student. Interactivity, gamification and other methods stimulate the interest of students and promote their motivation to learn. Multimedia materials, such as video presentations, audio lectures and virtual labs, help to improve understanding and retention of complex

concepts and create opportunities for hands-on exploration and experimentation. Online learning platforms make learning more accessible and flexible, allowing students to study at their own pace and communicate with other participants in the learning process. In general, digital technologies for teaching innovation open up new opportunities to improve the quality of education, providing effective and engaging learning that contributes to the continuous development and success of students.

International approaches to teaching with the help of digital technologies include interactive teaching methods, the use of video lessons and interactive tasks, as well as the use of immersive technologies to create interesting learning environments. Ukraine also actively uses e-textbooks, online resources and electronic platforms to organise the learning process. The use of digital technologies in teaching computer science helps students gain hands-on experience and develop the skills necessary for their future careers in information technology.

According to the results of a survey of teachers on the use of digital technologies in the educational process, the following conclusions can be drawn. Most teachers use digital technologies in their teaching practice, which indicates their confidence in the usefulness of these tools for the learning process. They also consider digital technologies to be important for teaching innovation, indicating a general awareness of their importance. Regarding the use of international and Ukrainian approaches to teaching with the use of digital technologies, the study determined that a minority of teachers prefer international approaches, but the majority use domestic methods. Their openness to cooperation with colleagues from other countries and readiness for self-improvement in the digital sphere are important. These results demonstrate the importance and relevance of introducing digital technologies into the educational process and the need for further development and professional development of teachers in this area.

The comparative analysis highlights the peculiarities of using digital technologies in teaching in Ukraine and France. Both countries actively use interactive whiteboards, online resources and individualised approaches to learning. However, Ukraine may face limited resources and a less developed digital infrastructure compared to France, which has a more accessible and developed infrastructure and more financial resources. Nevertheless, both countries are working together to innovate and develop modern approaches to education, which are positive signs for the future use of digital technologies in educational institutions.

The complexity of the study lies in the fact that data on the use of digital technologies in teaching is often not shared by different educational institutions and organisations, which may have different approaches to data collection and analysis. Researchers should examine the cultural and social contexts of digital technologies in teaching.

## Acknowledgements

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## Conflict of Interest

None.

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## **Використання цифрових технологій для інновацій у навчанні: порівняння міжнародних та вітчизняних підходів**

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### **Анотація**

**Актуальність.** Актуальність статті полягає в тому, що в ній порівнюються міжнародні та українські підходи до використання цифрових технологій в освіті з метою виявлення спільних рис, відмінностей та напрямів подальшого розвитку в удосконаленні викладання та навчання за допомогою технологій.

**Мета.** Дослідження має на меті порівняти та проаналізувати міжнародні та українські підходи до використання цифрових технологій у навчанні в Україні та Франції, виявити спільні та відмінні риси та визначити напрями подальшого розвитку у цій сфері.

**Методологія.** У рамках дослідження було проведено опитування викладачів закладів вищої освіти України, Європейського університету, Житомирського державного університету імені Івана Франка, Українського державного університету імені М.П. Драгоманова та Київського національного університету імені Т. Шевченка, а також порівняльний аналіз підходів до використання цифрових технологій у навчанні в освітньому просторі України та Франції.

**Результати.** Це дослідження показало, що використання цифрових технологій в освіті сприяє створенню динамічного та ефективного навчального середовища. Порівняльний аналіз використання цифрових технологій у навчанні математики та інформатики в Україні та Франції показує, що в обох країнах використовуються інтерактивні дошки, онлайн-ресурси та індивідуалізовані підходи до навчання, що свідчить про загальну зацікавленість у використанні сучасних технологій в освіті. Однак Україна стикається з проблемами, пов'язаними з недостатньою доступністю та розвиненістю цифрової інфраструктури, а також обмеженими фінансовими ресурсами для впровадження цифрових технологій в освітній процес порівняно з Францією.

**Висновки.** Україна та Франція активно працюють над інноваціями та розвитком сучасних підходів до освіти, що створює позитивну перспективу для майбутнього використання цифрових технологій у навчальних закладах.

**Ключові слова:** цифрові технології; інновації; віртуальна реальність; гейміфікація; ефективність навчання; мультимедійні матеріали; онлайн-платформи.