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Modern digital learning and simulation technologies in higher medical education: definitions, innovative potential

Aprendizaje digital moderno y tecnologías de simulación en la educación médica superior: definiciones, potencial innovador

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Abstract

Digital and simulative learning technologies have become especially popular and are being implemented in medicine. Consequently, this article aims to investigate the main digital learning and simulation technologies that are used in higher medical education. For this purpose, general scientific methods of research were used: analysis and synthesis. Based on the predictive method, the possible ways of solving some problems in digital medical education were demonstrated. Of separate importance was the use of content analysis, based on which the basic information materials concerning this problem were investigated in detail. In the results peculiarities of interpretation of digital and simulative technologies were defined, the problem of using digital technologies in modern medical education was characterized, the significance of simulative technologies in the system of training of future medics was

Resumen

Las tecnologías de aprendizaje digital y de simulación se han hecho especialmente populares y se están implantando en medicina. En consecuencia, este artículo pretende investigar las principales tecnologías digitales de aprendizaje y simulación que se utilizan en la enseñanza médica superior. Para ello, se utilizaron métodos científicos generales de investigación: análisis y síntesis. Basándose en el método predictivo, se demostraron las posibles formas de resolver algunos problemas de la educación médica digital. De importancia aparte fue el uso del análisis de contenido, en base al cual se investigaron en detalle los materiales informativos básicos relativos a este problema. En los resultados se definieron las peculiaridades de la interpretación de las tecnologías digitales y de simulación, se caracterizó el problema del uso de las tecnologías digitales en la educación médica moderna, se indicó la importancia de las tecnologías de

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indicated, the main stages of simulative training were investigated. It is noted that the key stage of simulation training is debriefing, where the analysis of basic errors takes place. In the conclusion, it is noted that the combination of digital and simulation technologies contributes to the improvement of the educational process as a whole.

Key words: higher medical education, simulation technologies, digitalization of education, analysis.

simulación en el sistema de formación de los futuros médicos y se investigaron las principales etapas de la formación de simulación. Se observa que la etapa clave de la formación con simulación es el debriefing, donde tiene lugar el análisis de los errores básicos. En la conclusión, se señala que la combinación de tecnologías digitales y de simulación contribuye a la mejora del proceso educativo en su conjunto.

Palabras clave: educación médica superior, tecnologías de simulación, digitalización de la educación, análisis.

Introduction

Today, the rapid development of new information and communication technologies has changed the nature of knowledge acquisition. Leading technologies have increased the ability to respond quickly to new advances in medicine, updated content and educational methods, and greatly expanded access to higher education. The use of digital innovations has also changed the role of teachers, in particular expanding their communicative role, making information more accessible and understandable to use.

Current trends in educational technology involve the use of digital elements of learning (Oleksiienko et al., 2022). Mastery of these techniques is an important part of the training of today's medical students, while also making extensive use of simulation devices. The practices of application and combination of traditional education and digitalization are different, but the main directions of further development are similar. It is true that the study of regional specifics of digitalization and automation of education in the medical industry has not been fully established since many elements still defy scientific classification and verification. Consequently, the purpose of this article is to analyze digital training and simulation technologies that are used in higher medical education. The main objectives, which will contribute to revealing the main goal of the article, are to define in more detail the definitions used around the world to characterize the proposed phenomena and to analyze the possibilities of their innovative potential. The emphasis, however, is also placed on the Ukrainian context and the prospects for the use of digital technologies in the training of medical university students (Radziievska et al., 2022).

This will make it possible to demonstrate the possibilities of the latest trained techniques based on technological advances in the realities of a country subjected to military aggression.

Theoretical Framework or Literature Review

Digital technologies in the medical education environment

The spread of digital technologies and the large-scale digitalization of society, the increase in digital learning platforms and resources cause changes in many areas of education, however, also in medical (Wakhlu et al., 2021). Modern trends in the labor market are related to the ability of future doctors to receive and properly interpret and use information (Jacob, 2020). Note that informatization as a technological advancement exposes users and future physicians to a variety of ways of implementing and solving individual information tasks or pressing needs (Rani et al., 2022). Proper application of communication, digital, information technologies contributes to the solution of a number of significant societal problems concerning the preservation of physical and mental health. Therefore, the demand in the labor market and the basic requirements for medical professionals have transformed (Wakhlu et al., 2021; Kushnir et al., 2019; Tsekhmister et al., 2021; Safonov et al., 2022). Such educational trends as “Lifelong learning”, continuous education, STEM-education, etc. are a necessary need in the environment of digital society because during higher education students have to acquire all the basic weighty necessary competencies (Pereira & Pereira, 2015). It is in the e-learning environment that these concepts are fulfilled based on information digital technologies and resources. In particular, in the conditions of Covid-19 and then in the realities of the Russian-Ukrainian war, teachers and students in Ukraine use various features of digital learning resources designed to support and

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organize communication in educational activities.

Note that the use of computer technology in education ("E-learning") entailed the emergence of new educational digital technologies, which influenced the quality of education, improving the interaction of teachers and students with computing technology, formed new means of teaching and educational impact (Salvati, 2019). Now, quite a debatable problem of interpretation of the term "digital technology" because many scientists interpret it differently. In particular Rani et al., (2022) believe that this concept should be understood as transferring and processing information through the use of special coding characters used in computer technology (Rani et al., 2022, p. 123-124). On the other hand, Kushnir et al. (2019) explain that digital technologies are technologies that use different digital signals to transmit information (p. 6-7). For this reason, the term "digital learning technologies" is understood as a type of information technology, which involves working with digital resources - objects contained in electronic form and designed to achieve certain learning objectives. Many modern scientists agree with this definition (Tsekhmister et al., 2021; Jena et al., 2021; Chen & Banerjee, 2021; Nourzaie et al., 2018; Banić et al., 2020). According to Salvati (2019), modern digital technologies contribute to a 20-30% increase in the effectiveness of classes (p. 236). The introduction of computer technology in the field of education has influenced the transformation of traditional means and technologies of education in the whole area (Salvati, 2019). Modern experts prove that the introduction of e-learning tools contributes to reducing the cost of organizing education, because it does not require the cost of renting facilities, travel to places of learning, etc. In addition, it contributes to lecture and seminar activities for a large number of individuals, improving the quality of training through the use of Internet resources, individual planning of time and duration of preparation for classes, the development of independence in students, the formation of opportunities for interdisciplinary discussion (See Table 1).

Table 1.
The main advantages of using digital technology in education

Benefits of using digital technology in education
Publicity, information from any location Reduced costs for the organization of training Widening of the target audience
Increased quality of education through a variety of interactive Internet resources
Wide range of educational platforms Individual time planning
Development of significant competencies: digital, informational, and critical thinking
Formation of interdisciplinary discussion High speed of information acquisition

Source: developed by the authors of the article

However, the application of educational digital technologies in medical education is associated with a number of weighty limitations: 1. predominantly training the future doctor is in the practical plane; 2. the need for computer capabilities and the Internet on a clinical base; 3. the need for higher education medical institutions specialists in IT technology and a specialized department for the implementation of IT technology (Salvati, 2019).

In order to overcome the above-mentioned negative points in the digital technology system, we propose the following solutions:

- Formation of powerful web portals, resources, platforms of medical educational institutions in the systemic network of medical institutions, medical institutions of the region (or state) as a means of analysis, processing of a large volume of educational information and materials of practical work of physicians (OECD, 2022).
- Formation of professional training of doctors in the system of web-supplemented learning (web-supplemented learning), which allows to develop a number of aspects of traditional training in a medical school (Nourzaie et al., 2018).

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- Study some courses only online using virtual simulation programs. This will contribute to both theoretical and practical skills.
- Introduction of mobile learning technologies (Andersone, 2020).
- Development of special medical training applications that would be in the public domain. Such apps should be aimed primarily at forming practical skills for future medical students. This stage also includes the use of various mobile programs for use in the professional training of medical students to investigate those problems that do not belong to the curricula;
- Application of VR platforms, virtual patients in professional training with optimization purpose.
- Use of special training platforms in order to conduct mass public courses (Kryvoshein et al., 2022).
- Formation of electronic libraries of medicine on the portals of educational institutions.
- In the process of training, it is also possible to use video recordings of medical consultations, which can be placed in the e-learning system.
- Combining fundamental learning with interactive learning. This, in turn, will involve role-playing activities (the student can act as a doctor, perform certain actions, make a diagnosis, analyze his or her own decisions, and justify treatment algorithms.
- Development of information and communication competence of applicants for medical education, consisting of the ability to properly use the media, communication, and information resources (Kryvoshein et al., 2022).
- Development of digital competence of future doctors as an important integral part of professional competence (Kryvoshein et al., 2022).

Methodology

This research is non-empirical (involves processing and applying the data of previous researchers, working with systematic reviews), fundamental (the article provides new results, which in the future will be useful for a new generation of researchers). So, the paper applies theoretical pedagogical research methods. In particular, based on the analysis the main subject of the research is divided into smaller elements (research on the state of use of digital technologies in medical education, characteristic of simulation technologies implementation, analysis of the main stages of simulation training). Through the use of synthesis, these elements are combined to form their own conclusions. Based on the axiological method, it was possible to move from general statements to their own advice. Based on the predictive method of research, it was possible to characterize the possible ways of solving some problems in digital medical education.

Based on content analysis it was possible to investigate in detail the main materials of written and visual information posted on the Internet. Using concretization, it was possible to highlight the main stages of the situational exercise in medical institutions. At the same time, the method of abstraction was used to model and describe some training simulation conditions suitable for improving the learning process.

Results and Discussion

Simulation training in the system of modern medical specialist training

Conditions for mastering and consolidation key practical skills, as close as possible to the real work of physicians, are created with the help of technical simulation learning tools (Gosai, 2017). In modern universities, simulation is understood as an educational methodology, which aims to “immerse” higher education applicants in interactive work through the establishment of real professional circumstances and challenges, but without risking the life or health of patients (Gosai, 2017).

Simulation training is based on the use of modern simulation technologies. We believe that simulation technologies are most optimally used in emergency and urgent care training, i.e., when practicing scenarios based on emergency medical care. Directly in such cases, it is likely to simulate the subject in a specific situation more fully and realistically, obtain key theoretical and practical skills, and practice the knowledge obtained without harming the health of another person (Han et al., 2022). The main areas of simulation training should be cardiopulmonary resuscitation, emergency medical care, mastering of medical manipulations, sterilization work, depending on the specialty - providing surgical, pediatric, gynecological, therapeutic care (Gosai, 2017).

Based onthe simulation of cardiopulmonary resuscitation there is organized a detailed training of skills to ensure the patency of the upper airways through the use of various modern methods. Students can also practice skills in mastering CPR techniques, testing basic

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resuscitation measures using an automatic defibrillator, and so on.

Medical manipulations based on simulation technology involve the organization of practical training skills of intravenous, intramuscular, intradermal, or subcutaneous injections (Han et al., 2022). Such medical manipulations require special simulation simulators by means of an adult or child's hand with a venous network. Note that the use of simulated blood in such simulators also adds realism. Maternity simulators consist of special functional mannequins that allow learning weighty theoretical and practical manipulations of their obstetrics. We are talking about Leopold's techniques, manual separation and removal of litter, external uterine massage (applying obstetrical forceps, etc.). Gynecological simulators consist of various models for mastering gynecological examination techniques (Gosai, 2017). This promotes the acquisition of practical knowledge in general diagnostic procedures by examining anatomical structures, inserting dilators and mirrors, and palpation.

Separately, there are special computerized simulators that help to practice the skills of examining the cardiovascular and respiratory systems with the simulation of typical and atypical situations in pediatrics. Such simulators should consist of simulated mannequins with different respiratory and cardiac pathologies. Surgical simulation simulators consist of virtual operating rooms, where a study of the main qualities of the operating and preoperative rooms is organized (Gosai, 2017). Traumatology students must work with a variety of simulated realistic human body bones with improvised fracture options.

Of particular importance in simulation, education are virtual simulation technologies that involve training organized by an appropriate number of computers in order to organize controls to reinforce the material (Prokopenko, 2021). Such virtual technologies influence the simulation learning process through the use of a variety of computer simulation programs (Ali, 2022).

Structure of a simulation session

Modern specialists distinguish several stages in the structure of simulation training, each of which is separate (Sherman et. al., 2021).

Consequently, at each stage students can obtain certain competencies

Table 2.
The main advantages of using digital technology in education

The main stages of the simulation lesson	
Stage name	Explanation
Pretest	An initial assessment of knowledge is carried out
Briefing	Conducting a briefing
Training to work on simulators	Familiarization of students with simulators, equipment, explanations
Simulation trainings	There is a detailed development of basic manipulation skills on stimulators. This stage can take place in groups or individually.
Teamwork (not all researchers are allocated to a separate stage)	Staging
Debriefing	A thorough analysis of the results obtained
Post-test	Final testing
Final stage	Summing up the results, anonymous questioning of students is possible

Source: developed by the authors of the article

The key stage of simulation education is the practical practicing of skills. Consequently, modern scientific literature considers debriefing to be a particularly responsible stage of simulation education. This term refers to a meaningful discussion of all scenarios after the completion of basic simulation activities (Li et al., 2020). Often in medical education, the term de-briefing also means a detailed analysis of the educational process, however, and based on a number of questions which are formed by the teacher. The main goal of de-briefing is to make students approach a constructive question from different points of view, so it will form more opportunities to choose different actions (Han et al., 2022). This stage is shaped in such a way that students focus on the main issues and determine the cause-and-effect relationships of events.

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Problems and prospects for the use of simulation training

Simulation training is a mandatory element of professional training, based on the use of special models of learning activities, allowing students to engage in professional activities (or perform a certain part of duties) in accordance with professional standards, learned rules of medical care (Pinheiro & Santos, 2022; Rak-Młynarska, 2022). As of today, several main classifications of simulation training are used, according to which they are categorized according to the method of work: verbal (use of role-playing games), standardized, work with simulators, physical or virtual models, patients on the screen (computer programs that allow training the necessary skills), electronic patients (dummies located in a simulated hospital environment) (Li et al., 2020).

The introduction and use of simulation technologies in the educational process has a number of advantages. In particular, we are talking about specific positives that Ukraine can get as a state and a powerful employer in the market of medical services:

- improvement of the quality of higher medical education;
- a tendency to reduce medical errors in Ukraine, respectively, an increase in the quality of medical services in general;
- increase in life expectancy of people.

Specific stakeholders who will hire graduates of medical universities will also have certain advantages:

- decrease in the level of medical errors made during work;
- the quality of services provided and trust in medical staff;
- increase the credibility of the institution among potential patients.

Probably the most obvious are the benefits for students. The use of simulation training technologies provides many advantages:

- the quality and relevance of the acquired knowledge, skills, and abilities; increasing the effectiveness of the education received;
- use of the personality-oriented approach in teaching;
- flexibility of the educational system for computer modeling of clinical scenarios, which allows students to choose appropriate topics independently. Flexibility is also guaranteed by the absence of territorial restrictions, quality access to the knowledge base via the Internet, etc. (with the ability to use different devices for individual work);
- tangible adaptability, since the use of modern digital technologies in the educational process, can be personalized to the required level;
- stimulus for the active development of cognitive work, improvement of analytical abilities and logical thinking, improvement of knowledge of evidence-based medicine, independent systematization and evaluation of information (acquisition of information competence), increased motivation for independent scientific research, use of creative skills and abilities;
- reduction of barriers between theory and practical use of acquired knowledge;
- the ability to control their own learning, awareness of the strengths and weaknesses of their training;
- the ability to study in asynchronous mode, while maintaining the ability to work and study at the same time;
- use of modern educational trends that exist in the information field;
- an increase in students' motivation to study;
- reducing the stress level during the first experience of working with medical instruments;
- work with rare pathologies and complex injuries (wounds, etc.) without threatening the life and health of patients;
- an unlimited number of attempts to develop the necessary skills.

Simulation technologies are also popular among existing doctors who undergo additional training and retraining at universities:

- prompt mastering of new work skills;
- opportunities for rapid development and improvement of skills and abilities using modern teaching methods;
- advanced training in accordance with the requirements of potential employers and the expectations of society;

Ease of use of simulation techniques is also beneficial for university teachers, as the availability of creating simulation scenarios allows you to model a variety of situations. In addition, everyday teaching work is greatly facilitated:

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- accessibility for a mass audience (many students will be able to perform practical tasks at the same time)
- opportunities to use various pedagogical techniques and methods, resources that will help students in their work;
- easier control over the learning process, monitoring the quality of the material learned, opportunities for tracking the success of student work;
- searching for incentives to improve the cognitive work of higher education students, doctors, improve their logical thinking, ability to use analysis, generalization, systematization, and other methods of operational information processing (Sherman et al., 2021).

At the same time, the effectiveness of simulation training also lies in the creation of appropriate conditions and compliance with the necessary stages (Tsekhmister et al., 2022). Obviously, without compliance with certain established rules, without a special organization of the educational process, the system of training specialists will not work so successfully (Tsekhmister et al., 2022). In particular, we are talking about compliance with the following requirements:

- for the effectiveness of the use of simulation for educational purposes, it is more expedient to use small groups of students, where the number of the latter per teacher will not exceed 10 people;
- appropriate theoretical training of students, including the use of methods of observing the work of experienced doctors;
- emphasis on independent work of higher education students, and reducing the role of the teacher to a consultant (Li et al., 2020);
- understanding by teachers of the process that there is a right to make mistakes in learning, so the reaction to the wrong work of higher education students should be appropriate;
- changing the tasks and methods of work of the teacher: the transition from strict assessment to observation, understanding the reasons why students made a mistake, finding out the circumstances that led to it, identifying the next actions of the student, etc;
- creating conditions as close as possible to the real situation. This will allow students to gain the necessary experience, work properly with instruments, feel the patient's reaction to correct / incorrect actions and their consequences, etc;
- emphasis on the use of necessary practical skills in simulation conditions;
- active use of distance learning and simulation training, management of independent and group training of students (Gosai, 2017);
- objectification of pedagogical control over the educational process, zero tolerance for bias, corruption, and manipulation;
- providing the necessary time for teachers and students. Which they can use for independent attendance of trainings and seminars, advanced training courses, etc.

Conclusions

Consequently, the use of digital technologies and simulation teaching methods is an obligatory part of the modern educational process. At the same time, the use of such tools requires both compliances with certain pedagogical methods and the creation of the necessary circumstances. In particular, the use of digital technologies in the training of future medics has several tangible limitations associated with excessive theoretical training, reduction of the practical component of training, the need for permanent Internet access at clinical bases, the need to involve IT and other specialists in medical schools, which would regulate and promote the use of digital technologies. Keeping additional staff and referring to this toolkit is generally quite valuable, but effective when combined with stimulation technologies. These technologies have a number of tangible advantages in use, which relate primarily to the acquisition of the necessary practical skills of work, with the life and health of patients remaining in complete safety. At the same time, the competent use of simulation technologies requires special conditions related to both the theoretical training of students and the correct organization of educational work on the part of teachers. In general, the list of requirements for the proper use of simulation is not fully formed, so this topic will require additional analysis in the future.

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