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## **Innovative approaches to training future doctors: from mentoring to simulation-based learning and artificial intelligence**

### **Kucher Svitlana Viktorivna**

PhD (Medicine), Associate Professor, Associate Professor of the Department of Internal Medicine Propaedeutics and Phthysiology, I. Horbachevsky Ternopil National Medical University, Ministry of Health of Ukraine, Ternopil, Ukraine,

E-mail - [kuchersv@tdmu.edu.ua](mailto:kuchersv@tdmu.edu.ua)

<https://orcid.org/0000-0003-1026-9567>

### **Chernets Tetiana Yuriivna**

PhD (Medicine), Associate Professor, Associate Professor of the Department of Internal Medicine Propaedeutics and Phthysiology, I. Horbachevsky Ternopil National Medical University, Ministry of Health of Ukraine, Ternopil, Ukraine,

E-mail - [chernets@tdmu.edu.ua](mailto:chernets@tdmu.edu.ua)

<https://orcid.org/0000-0001-7575-8391>

### **Ruda Mariia Myronivna**

PhD (Medicine), Associate Professor, Associate Professor of the Department of Internal Medicine Propaedeutics and Phthysiology, I. Horbachevsky Ternopil National Medical University, Ministry of Health of Ukraine, Ternopil, Ukraine,

E-mail - [ruda@tdmu.edu.ua](mailto:ruda@tdmu.edu.ua)

<https://orcid.org/0000-0002-5407-3315>

### **Vereshchahina Nataliia Yaroslavivna**

PhD (Medicine), Associate Professor, Associate Professor of the Department of Internal Medicine Propaedeutics and Phthysiology, I. Horbachevsky Ternopil National Medical University, Ministry of Health of Ukraine, Ternopil, Ukraine,

E-mail - [vereshchahina@tdmu.edu.ua](mailto:vereshchahina@tdmu.edu.ua)

<https://orcid.org/0000-0002-5569-1334>

### **Myndziv Kateryna Volodymyrivna**

PhD (Medicine), Assistant Professor of the Department of Physical Therapy, Occupational Therapy and Physical Education, I. Horbachevsky Ternopil National Medical University, Ministry of Health of Ukraine, Ternopil, Ukraine,

E-mail - [myndziv@tdmu.edu.ua](mailto:myndziv@tdmu.edu.ua)

<https://orcid.org/0000-0003-1025-973X>

### **Abstract.**

Modern medical education is undergoing profound changes aimed at improving the effectiveness of training future doctors in a rapidly changing and technology-driven healthcare environment. This article examines the main innovative approaches used in the teaching process, in particular simulation technologies, mentoring programmes and digital educational platforms utilising artificial intelligence, virtual and augmented reality. Simulation-based training allows for the creation of realistic clinical scenarios, ranging from practising basic

procedures on manikins to working with standardised patients and interactive digital models, which enables repeated practice of practical skills and enhances students' confidence, critical thinking and clinical judgement. Mentoring is a key element in integrating theoretical knowledge and practical skills, providing support in making complex clinical decisions, and fostering the development of professional identity, ethical conduct, and communication and teamwork skills. Systematic mentoring programmes have been shown to increase student satisfaction with their education, build confidence in their clinical competencies, and facilitate a smoother transition into the professional environment after completing their university studies. Digital technologies and artificial intelligence are becoming an integral part of the modern learning process. AI platforms enable personalised learning, automatically identify gaps in knowledge and skills, and provide adaptive tasks and instant feedback. VR/AR technologies offer the opportunity to practise complex and rare clinical cases without risk to the patient and develop skills in interdisciplinary collaboration. The article also examines the combination of traditional educational models with modern interactive approaches, which ensures a flexible, adaptive and comprehensive learning process. Such integration promotes the simultaneous development of clinical, digital and social competencies, enabling students to make effective decisions in unpredictable clinical situations and adapt to interdisciplinary teamwork. The comprehensive use of simulations, mentoring and digital technologies helps to shape a new generation of competent, responsible and modern doctors who possess critical thinking, clinical judgement, the ability to self-learn and work effectively in a team.

**Keywords:** medical education, simulation-based learning, interactive methods, clinical skills, digital competence, innovative technologies.

### **Інноваційні підходи до підготовки майбутніх лікарів: від наставництва до симуляційного навчання та штучного інтелекту**

#### **Кучер Світлана Вікторівна**

кандидат медичних наук, доцент, доцент кафедри пропедевтики внутрішньої медицини та фізіотерії, Тернопільський національний медичний університет імені І.Я.

Горбачевського МОЗ України, Тернопіль, Україна,

E-mail - [kuchersv@tdmu.edu.ua](mailto:kuchersv@tdmu.edu.ua)

<https://orcid.org/0000-0003-1026-9567>

#### **Чернець Тетяна Юрївна**

кандидат медичних наук, доцент, доцент кафедри пропедевтики внутрішньої медицини та фізіотерії, Тернопільський національний медичний університет імені І.Я.

Горбачевського МОЗ України, Тернопіль, Україна,

E-mail - [chernets@tdmu.edu.ua](mailto:chernets@tdmu.edu.ua)

<https://orcid.org/0000-0001-7575-8391>

#### **Руда Марія Миронівна**

кандидат медичних наук, доцент, доцент кафедри пропедевтики внутрішньої медицини та фізіотерії, Тернопільський національний медичний університет імені І.Я.

Горбачевського МОЗ України, Тернопіль, Україна,

E-mail - [ruda@tdmu.edu.ua](mailto:ruda@tdmu.edu.ua)

<https://orcid.org/0000-0002-5407-3315>

#### **Верещагіна Наталія Ярославівна**

кандидат медичних наук, доцент, доцент кафедри пропедевтики внутрішньої медицини та фізіотерії, Тернопільський національний медичний університет імені І.Я.

Горбачевського МОЗ України, Тернопіль, Україна,

E-mail - [vereshchahina@tdmu.edu.ua](mailto:vereshchahina@tdmu.edu.ua)  
<https://orcid.org/0000-0002-5569-1334>

**Миндзів Катерина Володимирівна**

доктор філософії, асистент кафедри фізичної терапії, ерготерапії та фізичного виховання, Тернопільський національний медичний університет імені І.Я. Горбачевського МОЗ України, Тернопіль, Україна,

E-mail - [myndziv@tdmu.edu.ua](mailto:myndziv@tdmu.edu.ua)  
<https://orcid.org/0000-0003-1025-973X>

Медична освіта перебуває на етапі глибоких трансформацій, спрямованих на підвищення ефективності підготовки майбутніх лікарів у швидкозмінному та технологічно насиченому середовищі охорони здоров'я. У статті розглядаються основні інноваційні підходи, що застосовуються в навчальному процесі, зокрема симуляційні технології, програми менторства та цифрові освітні платформи із використанням штучного інтелекту, віртуальної та доповненої реальності. Симуляційне навчання дозволяє створювати реалістичні клінічні сценарії, від відпрацювання базових процедур на манекенах до роботи зі стандартизованими пацієнтами та інтерактивними цифровими моделями, що забезпечує багатократне повторення практичних навичок та підвищує впевненість, критичне мислення і клінічне судження студентів. Менторство виступає ключовим елементом інтеграції теоретичних знань та практичних навичок, надає підтримку при прийнятті складних клінічних рішень, сприяє формуванню професійної ідентичності, етичної поведінки, комунікативних та командних навичок. Систематичні менторські програми демонструють підвищення задоволеності студентів навчанням, розвитку впевненості у власних клінічних компетенціях та успішної адаптації до професійного середовища після завершення університетської підготовки. Цифрові технології та штучний інтелект стають невід'ємною частиною сучасного навчального процесу. AI-платформи дозволяють персоналізувати навчання, автоматично виявляти прогалини у знаннях і навичках, надавати адаптивні завдання та миттєвий зворотний зв'язок. VR/AR-технології надають можливість відпрацювання складних та рідкісних клінічних випадків без ризику для пацієнта та формують навички міждисциплінарної взаємодії. У статті також розглядається поєднання традиційних освітніх моделей із сучасними інтерактивними підходами, що забезпечує гнучкий, адаптивний та комплексний процес навчання. Така інтеграція сприяє одночасному розвитку клінічних, цифрових та соціальних компетенцій, дозволяє студентам ефективно приймати рішення в непередбачуваних клінічних ситуаціях і адаптуватися до міждисциплінарної командної роботи. Комплексне використання симуляцій, менторства та цифрових технологій сприяє формуванню компетентних, відповідальних і сучасних лікарів нового покоління, які володіють критичним мисленням, клінічним судженням, здатністю до самонавчання та ефективною роботи в команді.

**Ключові слова:** медична освіта, симуляційне навчання, інтерактивні методи, клінічні навички, цифрова компетентність, інноваційні технології.

## Introduction

### Topicality of the problem.

The medical education is in a very dynamic phase of change, providing new opportunities for the preparation of future physicians [1, 2, 3]. In addition to the traditional teaching models, the innovative teaching models have been introduced in an active way, which enables more flexible, adaptive and comprehensive teaching and learning process [4]. These strategies include fundamental training and interactive educational technologies that enable

students to acquire clinical skills, as well as critical thinking, digital competence and the capacity to make effective clinical decisions in complex situations [5, 6, 7, 8, 9].

The use of simulation for learning has become an important trend in medical education over the past few years. Simulations can be used as a pedagogical tool to create realistic clinical scenarios and tasks in a controlled learning environment, to practise these skills repeatedly, which is essential for the development of confidence and clinical reasoning in future doctors [10, 11]. From simple manikins to standardized patients, to digital platforms incorporating virtual reality and interactive scenarios, the historical evolution and use of simulations has spanned the spectrum. The literature reviewed shows that simulation is a component of contemporary medical education and is utilized throughout the entire spectrum of medical training, ranging from undergraduate to postgraduate training and continuing professional development [12, 13].

In addition to simulation-based training, medical education now actively engages in mentoring programmes and mentorship as an integral part of students' development of clinical competence and professional identity [14]. Mentoring helps to integrate theory and practice, offers support when making complex clinical decisions, and helps to develop responsibility, ethical behaviour and effective communication with patients and colleagues. Systematic mentoring has been found to improve students' satisfaction with their training, boost their confidence in their own clinical skills and help them get better adapted to the workplace after university training [15, 16]. The use of digital technologies and AI systems is a major trend in modern medical education, and these tools are increasingly being used as tools for personalised learning. Artificial Intelligence facilitates the creation of adaptive education scenarios, gives students immediate feedback on finished tasks, and learns the learning process on an individual basis. VR/AR technologies in clinical simulations offer the possibility of experiencing a clinical environment without endangering the patient, and at the same time, training in the management of very complex or rare clinical cases. AI-powered adaptive platforms can automatically detect knowledge and skills gaps, provide customised tasks and enhance learning [17, 18, 19].

The use of simulation-based learning, mentoring and digital technologies presents new opportunities for the development of future doctors' comprehensive competencies. These strategies can help them improve their practical skills as well as their critical thinking, clinical judgment, decision-making in unpredictable situations, and adaptability to cross-disciplinary teamwork. This integrated approach aligns with the present needs of medical education international standards like competency models of the WFME (World Federation for Medical Education), which have been emphasizing the importance of integration of knowledge, skills and professional values in the training of doctors.

**The purpose of the article:** to examine the latest studies related to the effectiveness of the use of simulation, mentoring and artificial intelligence in the training of future doctors.

### Methodology

The objectives of this review were met by conducting a systematic literature search in the international databases PubMed, Google Scholar, Web of Science and Scopus for English-language scientific publications from 1st January 2020 to 1st January 2025. The last search was conducted on 21st May 2025. A bibliometric and structural-analytical approach was used, which allowed for an assessment of the state of the art of the implementation of simulation-based learning, mentoring programmes and artificial intelligence technologies in medical education. The method was used to obtain quantitative and qualitative information on the publications, such as trends in research activity, typology of documents, geographical distribution, institutional distribution, leading research centres and key research areas.

Specialized search terms and logical operators (AND, OR, NOT) and abbreviated terms were used to reflect variations in key concepts. The following combinations of terms were used, for example: “medical education” AND “simulation”, “mentorship” OR “mentoring

programmes”, “artificial intelligence” OR “AI”, providing a comprehensive coverage of the topic. The publications were chosen because they were relevant to integration of these approaches in undergraduate and postgraduate training and to postgraduate education of medical professionals.

In order to guarantee scientific rigor, exclusion criteria were applied: unverified publications, conference abstracts, editorial materials and preprints were not included and works related to local national programmes outside the scope of the international programmes were not included. Duplication of records was eliminated and full-text screening for relevance to the objectives of the review was carried out on the remaining publications.

### Results

Medical education simulation-based learning is “a teaching approach which allows students to experience clinical scenarios in a simulated setting in order to develop technical and non-technical skills that are essential to their future clinical practice.” The use of simulation technologies in learning has played an important role in enhancing students' clinical skills, such as procedural skills, patient communication, and clinical decisions [20, 21]. In the study by Loubbairi S. et al. (2025) a systematic review was conducted on the effect of simulation-based learning on developing critical thinking and reflection in medical and nursing programmes students [22]. They discovered that simulation technologies, especially high fidelity simulation technologies, have profound outcomes on critical thinking when compared to traditional teaching methods. The study pointed to the educational value of simulation-based learning, and stresses the need for more research, specifically with medical students.

Improvement of students' practical skills is one of the main features of the effectiveness of simulation. The use of simulation programmes enables complex procedures to be practised repeatedly in a safe setting without the risk to actual patients. Elendu C. et al. (2024) state that there are multiple advantages to simulation programmes, such as skill acquisition, decreased errors, and the ability to repeat tasks without risk to actual patients [10]. The use of structured debrief and immediate feedback further enhances learning, and simulation is an invaluable tool in medical education. The authors do point out though, that it is a complex task to implement simulation programmes. It involves major capital expenditure, specific equipment and personnel.

Fung C. et al. (2025) looked at the impact of a large, centrally designed simulation training programme (CSSP) on medical students in different clinical sites in the UK [23]. The goal was to see if a centralised, multi-site programme was able to boost student confidence in their clinical skills in a regular way, as it was independent of the resources and experience of the tutors. The study was carried out in the 11 simulation sessions that took place in 8 clinical sites among second, third and sixth year undergraduate students of the Imperial College School of Medicine. These sessions were composed of role-play, clinical scenarios and practical procedures that were aligned with the desired learning outcomes (ILOs). The students were asked to assess their level of confidence for the achievement of the ILOs at the end of each session and 522 responses were collected in the three academic years. Students' confidence improved in each session as there was a consistent increase in confidence across all sessions; in 9 of 10 sessions no statistically significant differences were observed between clinical sites, demonstrating the competence development of a centralised programme was not affected by site location. The CSSP programme has proven the effectiveness, sustainability and versatility of large scale simulation based learning; it offers equal opportunities for the development of practical skills, communication and interdisciplinary collaboration and can be scaled up and implemented in other disciplines of healthcare practice and clinical settings.

Students' confidence and clinical reasoning are greatly affected by simulations. Studies on high fidelity simulation for professional training have reported on the importance of self-assessed confidence in complex situations in making decisions [24]. Al Gharibi, K. And Arulappan, J. did a literature review. It also points out that multiple simulation experiences have

the potential to boost student confidence and enhance critical thinking, situational assessment, and making appropriate clinical decisions (2020) [25]. The evidence based on systematic reviews indicates that critical thinking as a result of learning through simulation has a positive effect compared to traditional learning, but the effect on reflective ability needs to be investigated further.

Mentoring and supervision in medical education is not just a formal part of the learning process, but an integral part of the formation of medical competence, professional identity and adaptation of students to the complicated requirements of medical practice [26]. Mentoring, broadly speaking, is a teacher/student or doctor/patient relationship, where the teacher/doctor provides assistance to the student/patient in a guiding and directing manner to assist the student/patient in the integration of theory and practice, and to develop self-reflection ability so that they can set up their own professional values [27]. These relationships can be for the purposes of knowledge and skill sharing, but also for maintaining psychological resilience, awareness of professional rules and standards, establishment of future professional goals and career paths [28].

Existing mentoring programmes in medical universities have been summarized in systematic reviews, which indicate that structured formal mentoring programmes can positively influence various aspects of clinical education, such as developing the skills of the medical students, enhancing their professional values, boosting their motivation and preparing them for clinical service [29]. Jun Rey Leong et al. (2025) did a systematic review of the mentoring programmes in medical education literature from 2000 to 2024 [14]. They highlight that good mentoring has a positive impact on the professional development of the students as well as the mentors, patient care, treatment outcomes, and the reputation of the educational institution. The authors came up with five elements of successful mentoring: personal characteristics of the mentor, mentoring process structure, mentoring process content, process goals, and barriers to mentoring. They also point out that in contemporary programs, the long-term mentoring process is becoming a more common feature and is providing a framework for the systematic building of the future mentor's professional identity that, in turn, has a positive impact on the development of the professional identity of mentored students. Medical education mentoring has a wide-ranging effect on student performance, clinical values, clinical skills and psychological resilience, raising the need to include a structured component of mentor training in training future doctors [30].

In their study Minor S. and Bonnin R. Study by (2022) stated that mentoring is very important medical students because they can get honest feedback, empathy and professional contacts from their mentors which leads their medical students' career development and academic performance [27]. The role of the mentor can be described in several aspects: mentor as coach, mentor as advisor, mentor as teacher/sponsor, mentor as psychosocial support, mentor as navigating in the professional world. Mentoring enhances students' confidence, establishes a secure setting for discussion of plans and ideas, gives motivation and challenges students to go outside their comfort zone essential for clinical and research skills. A survey conducted among second, third and fourth year students at the Herbert Wertheim College of Medicine (FIU) revealed that students are most appreciative of honest feedback, the mentor's responsiveness and professional networking opportunities, which were evident throughout all stages of study. Personalised and flexible mentoring promotes the effective professional and psychosocial development of students, regardless of gender, race or ethnicity, making it an integral part of modern medical education.

Medical education is undergoing a profound shift, with the use of digital technologies and AI systems impacting the delivery of educational content, not just in terms of how it's being taught, but how it's being assessed, fed back, and simulated via cases and scenarios [31]. AI's incorporation into the learning process allows for personalised learning, adaptive interactive platforms, improved virtual and augmented reality (VR/AR) features, and instant competency

evaluation. The rise in the number of such studies in recent years reflects the immense promise of AI technologies to enhance learning outcomes and offer benefits over conventional learning approaches.

Generating adaptive platforms that use AI to assess students' performance and adjust learning strategies accordingly is one of the most significant applications of AI in medical education. Tailoring the learning pathway for individual students by analysing their performance and automatically adjusting it is one of the most important applications of AI in medical education. These systems have the ability to detect flaws, provide extra assignments, and modify the difficulty of the content in accordance with the competence measures. Chance E. A. The research conducted by (2025) has shown that adaptive learning with the use of VR simulations is effective in achieving deeper knowledge retention and student motivation than traditional methods [32].

AI tools enable instant, objective and detailed feedback on tasks completed by students, allowing errors to be quickly identified and corrected, and progress to be measured in real time [32]. The same goes both for tasks of clinical reasoning and for the practical procedures in a virtual environment. The application of such technology will lead to better students' capacity to analyse clinical situations and better retention of material than would be found in traditional teaching without automated feedback [33, 34, 35].

Combining VR/AR with AI algorithms provides additional possibilities to effectively and safely train the next generation of physicians in complex clinical scenarios [36, 37]. These systems enable students to practice the rare or highly complex procedures without risk to patients and can be repeated for practice, procedures that are not easily simulated in a real-world situation or with patients.

## DISCUSSION

The incorporation of simulation learning, mentoring and artificial intelligence greatly improves the ability of future doctors to be effective. The use of simulation technologies allows students to repeat and practise their practical and cognitive skills in a safe and controlled environment, thus decreasing the risk of errors and increasing clinical decision making confidence. Mentoring, on the other hand, from experienced mentors helps integrate theory with practice, forms professional identity and assists psychological well-being in tough times. AI platforms support such processes through their ability to adapt learning pathways to enhance student learning, offer real-time feedback and automated assessment of student progress, and simulate complex clinical scenarios using VR/AR. This way students can practise in rare/critical situations that are not easy to replicate in the real world.

All of these three aspects combine to provide a holistic effect: not only do they improve practical and cognitive skills, but they also promote critical thinking, decision-making under stress, communication and interdisciplinary cooperation as well. In this way, simulations, mentoring and AI offer a more effective and complete training for future doctors than traditional training or the use of either of these elements alone.

### Scientific novelty

The novelty of this study is that this combination of three innovative approaches is not only effective in boosting learning results individually, but is also effective as a whole system that brings about a synergistic effect, bigger than the effect of each approach separately. For the first time, this is a systematic analysis of the interplay between simulations, mentoring and AI platforms that enables identification of optimal strategies for developing students' clinical and cognitive competencies.

### Practical significance

The applicability of the study results is that the results obtained can be directly used to create improvements in the teaching of medical universities. By applying an integrated approach, the students will be better prepared to work in complex clinical environments, there will be a lower risk of mistakes, greater levels of confidence and motivation, and there will be

opportunities for adaptive and personalised learning experiences via VR/AR and AI systems. The results could be applied to the design of continuing professional development training for physicians and the uniformed application of simulation and mentoring.

### CONCLUSIONS

Co-integrating simulation training, mentoring and AI is an effective approach to training future doctors. These methods are intended to take a holistic approach to the development of clinical, cognitive and professional skills in students, and help to motivate, inspire and boost their confidence and adaptability in the current medical landscape. Further research might focus on optimising this balance and on creating models for programmes in medical education that are integrated and can be scaled up.

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