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Original Research Article

VR technologies in the medical education

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Abstract

With the widespread adoption of modern technology, particularly computer simulations, medicine is also actively using technologies that allow students to master essential skills quickly and easily. Simulating complications that do not occur every day and representing rare events is a crucial component for improvement of knowledge of medical students. To address these critical issues for the development of medical education, we conducted an analysis and comparison between the groups of students to understand whether new technology improves necessary skills.

Keywords: VR technology, medical education, simulation teaching.

Introduction

The use of modern methods allows future doctors to develop their skills throughout their medical education. The use of virtual learning methods and a well-equipped simulation center contributes to increased patient safety (since not all procedures can be performed on a patient, even with the consent), and reduces the burden on medical institutions from large groups of students who find it difficult to develop certain clinical skills through direct contact with the patient during the preclinical stage of training [1]. Modern medical education is focused on training professional personnel, while also ensuring that patient protection is taken into account. The growing number of medical students must not compromise patient safety. Some skills cannot be practiced on patients during undergraduate studies, requiring the creation of simulations using various methods [3] [4].

Virtual reality in education is an environment in which students are immersed in a multimedia 3D, simulated environment that looks like reality and let students to interact, learn teamwork, practice skills and collaboration skills, manipulate medical equipment, and make diagnostic decisions [1], [2], [5]. The VR environment includes sensory stimulation and is designed to prevent learners from perceiving real-world influences beyond the simulation.

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Simulations can be broadly viewed as educational experiences that replicate real-world situations students will encounter in their practice [5]. Virtual patient is a type of VR that provides limited immersion, in which learners interact with a computer simulation of a patient situation [4]. Learners assume the role of a healthcare professional in the form of an avatar, such as a nurse or doctor, and make clinical decisions based on their assessment of the virtual patient. Trainees learn the role of the specialist they represent in terms of assessment, clinical diagnosis, treatment, and patient care, just as they would interact with a real patient [4]. A similar situation exists in the aviation industry, where it is impossible to demonstrate to students all the critical situations and tasks that need to be solved on board an aircraft. Just as in the aviation industry, a well-trained specialist is the foundation of preserving human lives, so in medicine, a well-trained physician is the foundation of safe and life-saving work in the professional field [1].

Patient safety is paramount in clinical education, and the long-standing "see-do-teach" teaching method is no longer considered acceptable by educators. Therefore, simulations play a key role in the ethically responsible education of physicians. This broad definition, encompassing the use of mannequins and various types of VR environments, distinguishes simulation environments by their ability to represent scenarios that medical students might not necessarily encounter during their practical training. This includes crisis situations, such as cardiac arrest and resuscitation—a core competency that requires maximum student engagement, which is difficult to achieve in a real-life situation for an undergraduate student [6].

Unlike videos or mannequins, virtual reality places students in a clinical situation. New technologies have been used for some time in medical education, either to train participants in specific medical procedures or to teach them how to use specific medical devices. It is very interesting to compare two main modern methods that improve skill acquisition [2]. These methods are: working with simulated dummies and working with VR technology. Virtual reality can provide trainees with the opportunity to immerse themselves in a designed, realistic, and, most importantly, safe environment where they can practice skills, interact and collaborate with peers or other specialists, make decisions regarding care and interventions, and manipulate equipment without fear of harming the patient [7]. VR simulations can be used in any area of clinical practice, but are particularly useful in settings with limited access to expertise, such as natural disasters or the perioperative period [3], [2].

Comparison of VR simulation with Mannequin-based simulation in medical education

VR simulation: Fully immersive digital environment, unlimited scenario variety (ED, ICU, disaster, home care, rare cases). Same scenario can be perfectly repeated for every student. Excellent for clinical reasoning, decision-making, sequence of actions, crisis management. Limited tactile

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(hands-on) feedback unless haptics is added. High initial setup cost, low long-term cost per student, minimal space required, scalable to large student groups. Psychological stress through immersion, less physical stress [4], [5]. Strong for leadership, communication, Interprofessional training, some loss of real human non-verbal cues [1]. Zero patient risk, safe environment to make serious mistakes. Ideal for novices. Automatic performance tracking: time to intervention, error rate, correct clinical pathways, objective scoring possible.

Mannequin simulation: Physical simulation lab, limited by mannequin capabilities and room setup, variability between sessions and instructors. Excellent for hands-on psychomotor skills, airway management, IV access, CPR depth and force, real instruments used. Feedback mainly instructor-based, subjective, varies by assessor, video review often required [4]. High realism stress (noise, crowding, physical presence). Real people in real space, better non-verbal communication and stress realism. High purchase cost, ongoing maintenance, dedicated simulation lab needed [2] [5]. Limited number of students at a time. Also safe, but limited number of attempts, equipment wears and instructor supervision required.

VR wins for objective assessment, for standardization and scenario diversity, for scalability and long-term efficiency, due to unlimited practice. Mannequin wins for stress fidelity, for human interaction realism, for tactile and procedural realism. (Table 1).

Table 1. Comparison of VR simulation with Mannequin-based simulation in medical education

Aspect	*VR Simulacion*	*Mannequim Simulation*
Environment	Virtual, immersive	Physical, lab-based
Repetition	Unlimited	Limited
Hands-on skills	Limited	Excellent
Decision-making	Excellent	Good
Feedback	Automated, objective	Instructor-based
Cost efficiency	High (long-term)	Lower scalability
Rare scenarios	Excellent	Limited
Team interaction	Good	Excellent
Maintenance	Low	High

Material and methods

To address these critical issues for the development of medical education, we conducted an analysis and comparison between two groups of students. Each group included two groups of 20 students, for a total of 40 students.

Our study utilized reinforcement of two skills: arterial catheterization and venous catheterization, both with blood sampling for subsequent analysis to diagnose pathological conditions.

The study included third-year university

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students who completed pathology modules along with skills learned in parallel with the study of pathological processes. In one case, training was conducted using dummies in a simulation center; in the second case, training was conducted first on dummies and then reinforcement of acquired knowledge using immersion VR technology.

Assessment in both groups was conducted using the OSCE exam, which allowed for the assessment of acquired knowledge. An Objective Structured Clinical Examination (OSCE) is a performance-based assessment used in healthcare education to evaluate clinical competence, including skills, communication, and decision-making. Candidates rotate through timed, standardized stations, interacting with simulated patients or mannequins while being rated by examiners using objective checklists.

Students were randomly selected from their third year of study, having already completed the norms and pathology modules, as well as the clinical skills included in these modules. This meant they had also completed training in venipuncture and arterial puncture with blood sampling. The selected students were then divided into two groups. One group of students was required to perform venipuncture with blood sampling for a complete blood count, while the other was required to collect blood for blood gas analysis.

The OSCE checklist was used for the assessment, and 10 competencies were assessed at each assessment station. (Table 2, Table 3). As we've observed, both groups achieved good results, with high grades, but the group using new technologies showed better results, indicating the university is taking the right path to improve student training.

An independent samples t-test demonstrated significantly higher OSCE scores in the moulage + VR group compared to the moulage-only group, $p < 0.001$.

Table 2. OSCE checklist for evaluating groups trained in Venous catheterization

N	Competencies	Blood Sample Collection (Venipuncture) using moulages	Blood Sample Collection (Venipuncture) using moulages +VR technology
1.	Performs hand hygiene, putting on gloves, introduces self and confirms patient identity	20	20
2.	Explaining the stages of the manipulation to the patient, Obtaining the patient's consent to the manipulation	20	20
3.	Applies tourniquet correctly	19	20
4.	Selects appropriate vein	18	20
5.	Clean the insertion site with an antiseptic solution (chlorhexidine or alcohol-based)	17	20
6.	Selects correct catheter size	19	19

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7.	Flushes catheter and tubing, removes air	17	20
8.	Venipuncture, Insertion of a peripheral venous catheter	17	20
9.	Collect blood	18	19
10.	Removes needle safely	18	18
11.	Expels air bubbles from syringe	17	19
12.	Releases tourniquet at correct time	17	19
13.	Caps syringe correctly	16	20
14.	Common complications of Venous sampling Hematoma, thrombosis, infection, pain (student must pronounce	18	18
	Total score:	**252**	**270**

Table 3. OSCE checklist for evaluating groups trained in Arterial catheterization

N	**Competencies**	**Blood Sample Collection Arterial for ABG using moulages**	**Blood Sample Collection (Venipuncture) using moulages +VR technology**
1.	Performs hand hygiene, putting on gloves, introduces self and confirms patient identity	20	20
2.	Explaining the stages of the manipulation to the patient, Obtaining the patient's consent to the manipulation	19	19
3.	Applies tourniquet correctly	19	20
4.	Selects appropriate vein	18	20
5.	Clean the insertion site with an antiseptic solution (chlorhexidine or alcohol-based)	17	20
6.	Selects correct catheter size	19	19
7.	Flushes catheter and tubing, removes air	17	20
8.	Venipuncture, Insertion of a peripheral venous catheter	18	20
9.	Collect blood	18	20
10.	Removes needle safely	18	18
11.	Expels air bubbles from syringe	19	19
12.	Releases tourniquet at correct time	17	19
13.	Caps syringe correctly	18	20
14.	Common complications of Venous sampling Hematoma, thrombosis, infection, pain (student must pronounce	18	18
	Total score:	**255**	**269**

The tables show that in most cases, students in the VR group scored the maximum 20 percent, which is 100%. This result was partly achieved with the help of a virtual simulator, which does notallow students to move on to the next step without completing the previous one. As we can see, this proved to be very effective at these stages of medical

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education. We observed that students achieved good results in both groups, with high grades. New technologies allow for the development of even complex skills, such as arterial catheterization and blood sampling for ABG. Figure 1.

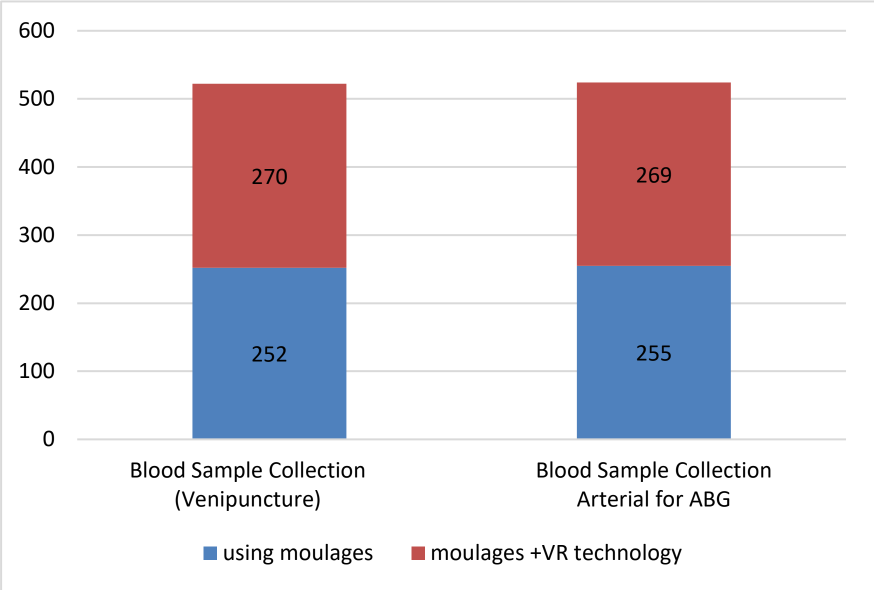

Figure 1: OSCE checklist for evaluating groups trained in Arterial catheterization and venipuncture

VR technologies not only enable student learning but also enable instructors to develop assessment capabilities at various stages of learning. Compared to the OSCE, VR technologies can be integrated into a more complex stage of performance assessment, the stage when instructors demonstrate their skills as part of a complex, integrated scenario. Figure 2.

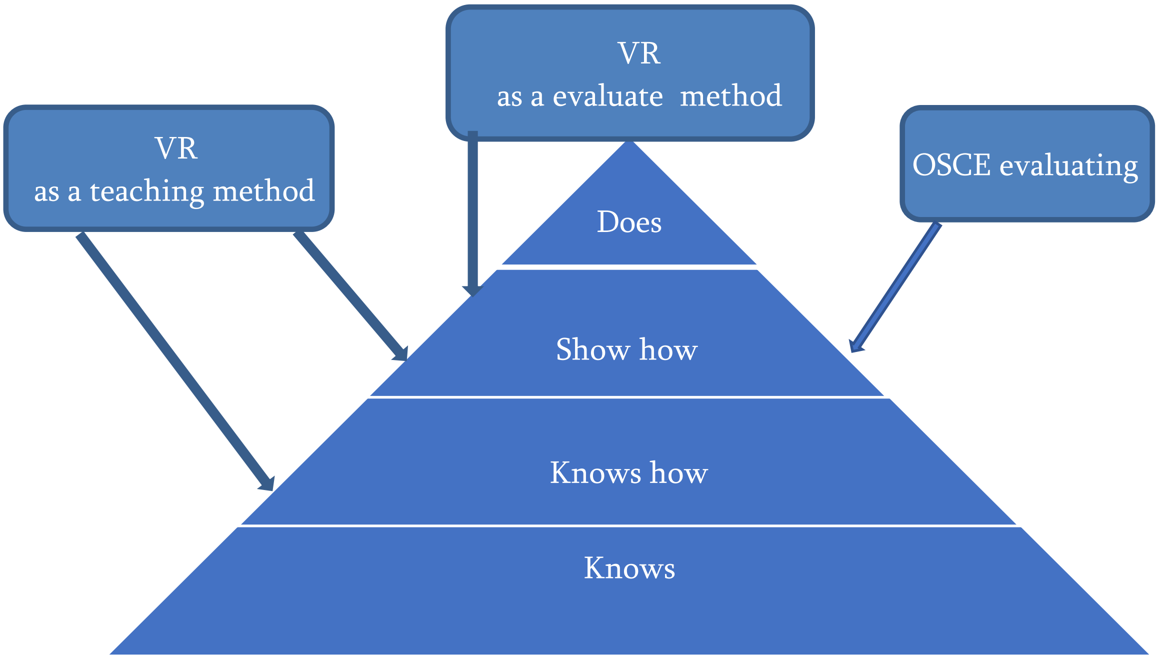

Figure 2: VR technologies

Analyzing the obtained data, we can conclude that the use of new technologies is justified and produces results that are extremely important for the training of

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experienced, well-trained and erudite specialists in medicine.

Conclusions

The obtained results, although they allow for drawing conclusions, require further extensive research to determine the feasibility of new teaching methods, and also require the involvement of a larger number of students at both the undergraduate and residency levels and the creation of more complex scenarios for evaluation.

Although VR is a powerful technological tool in medical education, its impact on self-awareness and how digital experiences can influence our choices and moral and ethical Rights remains unclear and a subject of debate.

With advances in technology, including augmented reality and haptic feedback, which create realistic sensations of touch and manipulation of equipment in virtual procedures, these technologies are the future of medical education and are likely to remain so for a long time.

Future research is definitely needed to evaluate the development of these skills across educational stages, in other courses, and in the integration of other skills in other subjects, such as emergency medicine, critical care. The role of new technologies is being thoroughly investigated, and whether they lead to student overload and burnout. It's also important to evaluate the time spent on immersive technologies, and determine whether VR technology increases or decreases learning time.

Acknowledgement

Our university offers students the most modern educational opportunities, from modern literature and 3D anatomical systems to models and immersive VR technologies. Students graduating University “Geomedi” are successfully passing challenging international exams and advancing to the next level of education. Thousands of them have already completed their educational journeys and are successfully fighting for the lives and well-being of patients. Some of them are even teachers themselves, teaching at top universities around the world.

This article is dedicated to Mr. Tamaz, Vice Rector for Organizational Affairs. This represents his enormous contribution to the development of modern teaching methods at our university, starting with one of the largest simulation centers in the Caucasian region for using cutting-edge VR technologies.

VR ტექნოლოგიები სამედიცინო განათლებაში

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აბსტრაქტი

თანამედროვე ტექნოლოგიების, განსაკუთრებით კომპიუტერული სიმულაციების ფართოდ გავრცელებასთან ერთად, მედიცინა აქტიურად იყენებს ტექნოლოგიებს, რომლებიც სტუდენტებისათვის საშუალებაა სწრაფად და მარტივად დაეუფლონ აუცილებელ უნარებს. მედიცინის განვითარებისათვის და გართულებების შემცირების მიზნით, სიმულაცია, ისეთი გართულებების მოდელირება, რომლებიც ყოველდღიურად არ ხდება და იშვიათ შემთხვევებს წარმოადგენენ, უმნიშვნელოვანესი კომპონენტია.

დასახული მიზნის მისაღწევად, ჩავატარეთ კვლევა, რათა გაგვერკვია, აუმჯობესებს თუ არა ახალი ტექნოლოგია სამედიცინო სტუდენტებში საჭირო უნარებს ინფორმაციის ასათვისებლად. მისი შედეგების ანალიზმა დაადასტურა კვლევის მიზანი.

საკვანძო სიტყვები: VR ტექნოლოგია, სამედიცინო განათლება, სიმულაციური სწავლება.

References

1. Chukwuka Elendu, Dependable C Amaechi, Alexander U Okatta, Emmanuel C Amaechi, Tochi C Elendu, Chiamaka P Ezeh, Ijeoma D Elendu, The impact of simulation-based training in medical education: A review, Medicine (Baltimore). 2024 Jul 5;103(27)
2. Mahnaz Samadbeik, Donya Yaaghobi, Peivand Bastani, Shahabeddin Abhari, Rita Rezaee, Ali Garavand, The Applications of Virtual Reality Technology in Medical Groups Teaching, J Adv Med Educ Prof. 2018 Jul;6(3):123–129.
3. Tim Swanwick, Kirsty Forrest, Bridget C. O'Brien, Understanding Medical Education: Evidence, Theory, and Practice 3rd Edition, Wiley-Blackwell January 4, 2019 600 pages
4. Gabrielle Finn, Helen Church, Megan Brown, Matthew Byrne, Dr Neel Sharma, Oxford Handbook of Medical Education in Practice (Oxford Professional Practice) 3rd Edition, Oxford University Press May 12, 2025 464 pages
5. Tejinder Singh, Piyush Gupta, Daljit Singh, Principles of Medical Education Fifth Edition e J.P. Medical Ltd 2021.
6. Shruti Goswami, Gunjan Badwaik, Anjali Borka, Pratibha Deshmukh, Integration of Artificial Intelligence and Virtual Reality in Undergraduate Medical Education: A Review of Emerging Trends and Applications European Journal of Cardiovascular Medicine, Volume 15 Issue 6 (June, 2025) | Pages 219 – 221
7. Siyu Zhou, Diane Gromala, Leyu Wang, Ethical Challenges of Virtual Reality Technology Interventions for the Vulnerabilities of Patients With Chronic Pain: Exploration of Technician Responsibility, J Med Internet Res,. 2023 Dec 4;25

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