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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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TRANSFORMING MEDICAL EDUCATION IN KAZAKHSTAN: THE POTENTIAL OF VIRTUAL REALITY FOR ENHANCING THE LEARNING EXPERIENCE

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Abstract.

Background: The potential of virtual reality (VR) in medical education in Kazakhstan proved substantial, offering innovative learning methods and creating secure, interactive training environments that facilitated the acquisition of both theoretical knowledge and practical skills.

Materials and methods: This study aimed to evaluate the application and effectiveness of virtual reality in medical education through a survey conducted with 53 students and 20 teachers. To assess the perceptions and satisfaction with VR in medical education, a survey was conducted utilizing a scale from 1 to 10.

Results: Findings from the survey revealed that students perceived significant advantages in using virtual reality to grasp complex medical concepts and hone clinical skills. They appreciated the opportunity to apply theoretical knowledge in practice, the availability of high-quality content across various disciplines, and the safe learning conditions provided.

Conclusion: Teachers recognized virtual reality as a valuable educational tool but highlighted some challenges, including insufficient training and limited access to equipment. Addressing these obstacles is crucial for the successful integration of virtual reality into training programs, thereby unlocking its full potential and enhancing educational outcomes.

Key words. Virtual reality, medical education, educational technologies, teachers, students, innovations in education.

Introduction.

Traditional medical training has historically relied on direct interaction between academics and students, focusing on theoretical instruction and practical training in clinical settings. However, traditional methods present significant limitations, such as limited training hours, difficulty in providing extensive hands-on experience, and challenges in teaching complex concepts. These constraints, combined with limited access to real clinical situations and the high costs of training, have prompted the exploration of new technologies. The integration of technologies such as VR offers a solution to these issues, allowing students to gain practical experience without compromising patient safety and providing more flexible and accessible training opportunities [1].

Recently, there has been a growing trend toward integrating advanced technologies, particularly VR, into medical education. More educators are recognizing the importance of leveraging these new tools to enhance the learning experience [2].

Virtual reality (VR) and augmented reality (AR) represent significant technological innovations that create immersive learning environments. VR enables complete immersion in a simulated reality through devices like headsets and gloves, while AR overlays virtual objects onto the real world, fostering interactive learning experiences. These technologies started being implemented in education towards the end of the 20th century and their usage has significantly expanded with technological advancements.

Previously reliant on in-person sessions, recent efforts have emphasized integrating technology into medical education. Over the past two years, Guanjie et al. conducted a meta-analysis highlighting the rapid advancement of VR in this field. Their study demonstrated that VR significantly enhances the assimilation of medical knowledge, with students trained via VR outperforming those using traditional methods in examinations [3]. In Kazakhstan, for instance, systems like ClassVR from Oxford enable students to learn like through engaging 3D models, while Oxford Medical Simulation provides realistic surgical scenarios to enhance decision-making skills in a safe environment [4]. The involvement of an instructor during VR sessions increases student engagement and satisfaction with the learning process [5].

Augmented reality further enhances virtual reality by integrating virtual objects within real-world environments, allowing interaction between the virtual and the physical. These technologies also aid in studying anatomical models and integrating MRI and CT imaging [6]. Ongoing studies continue to highlight the significance of VR and AR in surgical training and various other areas of medical education [7-9].

After examining the use of virtual reality across Europe [10], America [11], and Asia [12], it is evident that this technology has significant potential for improving medical education in Kazakhstan. VR and AR present clear advantages in health education, equipping future doctors with essential skills while minimizing risks to patients [13]. The goal of this article is to explore the transformative potential of VR in medical education, particularly within the context of Kazakhstan, and assess its impact on training future medical professionals.

VR for Modern Medical Education and Training.

Integrating VR into medical education revolutionizes healthcare training by offering immersive, risk-free environments for skill development [14]. For instance, surgeons can practice procedures, make mistakes, and refine techniques without jeopardizing patient safety. This technology enables learners to approach real operations as rehearsed scenarios, significantly enhancing confidence and proficiency while safeguarding patients. Modern VR systems support anatomical visualization [15,16] and decision-making within secure environments [14].

VR also advances distance learning through virtual training

sessions, promoting international collaboration in medical education [17]. These technologies have the potential to revolutionize how healthcare practitioners acquire skills, improving learning outcomes and access to quality education [18]. VR simulations enhance decision-making, hand-eye coordination, and performance, while fostering teamwork and communication skills through collaborative exercises [14].

AR complements VR by combining virtual elements with real settings, enhancing engagement and facilitating hands-on learning [19]. While VR and AR offer on their own, a balanced approach is necessary for their integration into conventional training frameworks [20]. Both theoretical and practical experiences are essential for students, as repeated practice enhances competence. VR motivates students and fosters skill development, making it a valuable addition to curricula [21].

Educational reforms require advanced training standards for medical professionals, especially in specialized fields like medical physics. The intersection of medical education with artificial intelligence further advances teaching methodologies, emphasizing the need for quality clinical data [22].

In summary, the use of VR and AR technologies in medical education can represent a significant development in training methodologies, enhancing the educational experience for future healthcare professionals while addressing the inherent limitations of traditional practices.

VR and AR are making significant strides in medical education by providing cutting-edge tools for immersive simulations [23]. These technologies allow students to explore anatomical structures and procedures in a hands-on manner, deepening their understanding of complex medical concepts. Notable institutions like King's College London and the University of Oxford have successfully incorporated VR into their curricula to help students navigate intricate subjects more effectively [2]. Furthermore, VR and AR facilitate distance learning, enabling remote access to training and minimizing preparation time for clinical practice. This flexibility enhances accessibility, allowing learners to pursue their education without being constrained by physical locations or rigid schedules.

However, the integration of VR and AR also presents several challenges. High-end equipment and software requirements can impede widespread adoption, and there are significant barriers related to accessibility, both in terms of the necessary devices and the skills needed to use them [5]. Additionally, extended use of VR can result in physical discomfort such as eye strain or dizziness, and may lead to social isolation, which can hinder the development of essential communication skills [24]. Ethical considerations regarding data privacy and the effects of long-term engagement with immersive environments further complicate the educational use of these technologies. Moreover, the financial burden of acquiring VR and AR equipment can be a substantial hurdle, particularly for institutions with limited budgets.

Despite these challenges, the ongoing advancements in technology play a vital role in shaping medical education's future [25]. Incorporating VR and AR into training programs is essential for improving the quality of education for emerging healthcare professionals.

Therefore, while the potential benefits of VR and AR in medical education are considerable, their implementation must be approached thoughtfully. A balanced perspective that acknowledges both the advantages and the limitations of these technologies is crucial for maximizing their effectiveness in medical training and progressing education in an increasingly digital landscape.

Medical Education in Kazakhstan.

Incorporating VR into Kazakhstan's medical education system offers immense potential to revolutionize traditional teaching practices. VR provides immersive, three-dimensional simulations replicating complex medical scenarios, allowing students to hone their skills and perform procedures in a secure, controlled environment. However, VR adoption has been slower than expected, hindered by challenges such as inadequate resources, restricted access to technology, and skepticism among some faculty regarding its effectiveness.

Traditional medical education in Kazakhstan primarily emphasizes direct interactions between students and instructors, alongside hands-on clinical practice. While valuable, this approach faces limitations, including restricted training hours, concerns about patient safety, and difficulty replicating rare medical conditions. Consequently, there is growing enthusiasm for integrating VR into curricula to provide students with a broader spectrum of practical learning opportunities.

Some medical institutions in Kazakhstan are beginning to implement VR simulators for training. These technologies are particularly effective for simulating surgeries, diagnostic tasks, and emergencies, improving cognitive, motor, and decision-making competencies. This gradual shift underscores the necessity to modernize medical education and prepare future healthcare professionals with advanced, globally competitive expertise.

This study examines the potential of VR to advance medical education by evaluating its influence on student learning outcomes and teaching efficacy. By bridging the gap between theoretical instruction and practical application, VR enables students and educators to engage with complex scenarios. The research uniquely addresses the challenges and prospects of VR integration in Kazakhstan, where advanced educational technologies are still in their early stages. This initiative aims to elevate the system to international standards, contributing to a more innovative and effective healthcare sector. The purpose of this is to analyse the perception of VR among educators and students in the educational process with an emphasis on its advantages and limitations.

In the study of the perception of VR in medical education in Kazakhstan, a consensus scale was utilized to assess collective agreement among participants on key aspects of VR in education. This method effectively measures the level of agreement between students and teachers regarding the effectiveness and potential of VR within the educational process.

Materials and Methods.

Study Participants:

The study was conducted among teachers and students of the Higher School of Medicine of NJSC "Kokshetau University

named after Sh. Ualikhanov", including international students and English-speaking teachers from April 20 to June 10, 2025. The method of targeted sampling was used to select respondents with experience in using virtual reality.

The study was conducted among two groups: 53 medical faculty students and 20 instructors. Participants were selected using purposive sampling, taking into account their experience with VR technologies in educational settings. All participants voluntarily agreed to take part in the study and signed informed consent forms. None of the participants had contraindications to VR use, such as severe motion sickness or other medical limitations.

Ethical Approval:

From October 16, 2024 to December 16, 2025, as part of the Bolashak program, the author completed a research internship at King's College London, where a questionnaire was developed and official ethical approval of the study was obtained (№ 42426). The permit was extended to the questionnaire in the period from April 15 to June 15, 2025. The empirical part of the study was carried out in Kazakhstan.

The study was conducted among teachers and students of the Higher School of Medicine of NAO "Kokshetau University named after Sh. Ualikhanov", including international students and English-speaking teachers. The method of targeted sampling was used to select respondents with experience in using virtual reality.

Participation in the study was voluntary, anonymous and in accordance with the ethical standards of King's College London and the international principles of human research.

Inclusion and Exclusion Criteria:

Participants with at least one month of experience using VR and regular engagement with VR-based activities were included in the study. Individuals without prior VR experience or those with medical contraindications were excluded. Susceptibility to motion sickness was preliminarily assessed using a short questionnaire.

Data Collection Procedure:

To evaluate the perception and satisfaction with VR use, participants were provided with interactive sessions, after which they completed questionnaires rating their experience on a scale from 1 to 10, allowing quantitative assessment of satisfaction levels. The surveys were administered via the online platform Google Forms. The duration of VR interaction ranged from 15 to 30 minutes.

Instruments and VR Simulation Platform:

The technological component of the study was based on the use of the Oculus Quest 2 headset, a standalone virtual reality system that provides high mobility, ease of deployment, and broad accessibility for educational settings. This device offers adequate computing performance, hand-tracking capabilities, and ergonomic controller design, making it suitable for immersive clinical simulation and interactive learning tasks. The software used in the study included a set of validated educational VR applications. These comprised Anatomy VR, which provides detailed 3D visualizations of human anatomical structures, and specialized clinical procedure simulators such as Surgical Simulator and Medical Procedure VR. Together, these programs allowed participants to practice diagnostic steps, procedural techniques, and communication with virtual patients in a controlled and replicable environment. The content was selected to ensure maximal realism and representativeness of medical scenarios, while the visual resolution, interactivity, and user interface aligned with international standards for modern VR-based medical training. The practical phase of the study was conducted in a dedicated VR simulation room at the Higher School of Medicine, equipped with the AcademiX VR platform. This system integrates large-screen visualization, patient-scenario modules, and VR headsets, enabling simultaneous observation and performance of clinical simulations. Participants engaged with virtual patient cases, interpreted clinical parameters, and executed simulated medical procedures, which allowed for the standardized

Figure 1. *Faculty member interacting with the AcademiX VR patient-simulation module during a clinical scenario.*

Figure 2. *Medical students engaging with the AcademiX VR platform during simulated clinical exercises.*

Figure 3. *Student completing an individual VR clinical scenario using the Oculus Quest 2 headset.*

assessment of their experience and level of engagement. To illustrate the operational environment and provide transparency of the implementation process, Figures 1–3 present examples of how VR technology was used by faculty members and students during the study.

This image demonstrates how teaching staff performed VR-based diagnostic and procedural tasks as part of the study protocol. The figure illustrates group participation in VR training sessions, including real-time observation of scenarios displayed on the simulation screen.

This image shows the immersive nature of the individual VR experience and reflects the setting in which data collection was conducted.

Data Analysis:

Statistical analysis was performed using SPSS software (version 26). To assess the significance of differences between groups, a two-tailed nonparametric Mann–Whitney test was applied, as the data distribution was unpredictable and the number of observations was limited. The level of statistical significance was set at $p < 0.05$.

Spearman's correlation analysis was used to evaluate relationships between variables. For comparisons of mean scores on the rating scale, median values and interquartile ranges were analyzed. To determine the reliability of the findings, 95% confidence intervals were calculated.

It is important to note that the original dataset did not specify which statistical tests were applied, which complicates the interpretation of p-values. Therefore, to ensure analytical accuracy, the Mann–Whitney test was chosen as the most appropriate method, given the small sample size and lack of assumptions regarding normality.

Limitations of the Study.

This study has several limitations that should be taken into account when interpreting its findings. First, the limited number of participants (53 students and 20 instructors) reduces the overall statistical power and may affect the generalizability of the results. Second, the use of self-reported questionnaires and survey methods may introduce subjectivity and socially desirable responses, potentially distorting participants' true perceptions. Third, the study was conducted within a single educational institution in Kazakhstan, which restricts the applicability of its conclusions to other educational or cultural contexts without further investigation. Moreover, the short duration of the study did not allow for assessment of the long-term effectiveness of integrating VR technologies into the educational process. Finally, certain factors—such as instructors' technical preparedness and the level of technological infrastructure—may have influenced the perception of VR; these variables warrant more in-depth and structured analysis in future research.

Results.

Data analysis showed that most participants positively evaluate the use of VR in medical education. The main indicators obtained in the course of the study are presented in Table 1.

According to Table 2, the average score for the impact of VR on understanding complex concepts was 8.5 ± 1.2 out of 10,

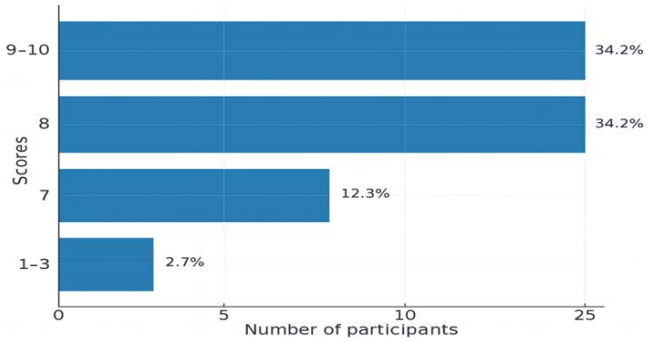

Figure 4. *Histogram of Satisfaction Ratings for the Use of VR (n = 20).*

Table 1. *Characteristics of Study Participants (n = 73).*

Parameter	Value
Age, years	20–25 (mean 22.3 ± 1.4)
Gender	Men — 40 (55%) Women — 33 (45%)
Level of Education	Students — 53 (73%) Teachers — 20 (27%)
Experience with VR, years	0–2 years — 68%, >2 years — 32%
Satisfaction Level	Mean score 8.2 out of 10

Table 2. *Assessment of VR Impact on Understanding Complex Concepts (n = 73).*

Question	**Rating (from 1 to 10)**	**Median**	**Percentage of responses ≥ 8**
To what extent does VR enhance the understanding of complex concepts?	8.5 ± 1.2	9	70%
To what extent does VR assist in practical training?	8.3 ± 1.4	8	68%
Overall satisfaction with the use of VR	8.2 ± 1.3	8	65%

with 70% of respondents rating it as 8 or higher. This indicates a high level of satisfaction and effectiveness of VR in mastering complex topics. Additionally, 68% of instructors noted that VR contributes to practical training, and 65% expressed overall satisfaction with the use of this technology (see Table 2).

Positive evaluations indicate that 85% of instructors incorporate VR into the educational process, with 45% describing their experience as "excellent" and another 45% as "good." The most common area of VR application was medical disciplines (65%), confirming its significance in the field of education. Figure 4 illustrates the distribution of instructors' satisfaction levels on a ten-point scale, demonstrating the predominance of high scores, which indicates a positive assessment of VR technologies. The survey results further confirm that VR integration enhances learning motivation and student engagement, with 90% of instructors reporting substantial improvements in students' learning activity and practical skill development after using virtual educational tools.

Statistical analysis revealed significant correlation relationships: there was a positive correlation between the level of satisfaction with VR and its perception as an effective educational tool ($r = 0.45$, $p = 0.04$), confirming the importance of user perception and experience in achieving educational outcomes (Table 3).

Table 3. *Comparison of VR perceptions by teachers and students.*

Scale	Teachers (Me [IQR])	Teachers (Me [IQR])	p-value
Efficiency	6 [5-8]	8 [7-9]	0.02*
Usefulness	7 [6-8]	8 [7-9]	0.04*
Engagement	6 [5-7]	8 [6-9]	0.01*

**Students generally rated VR higher than teachers ($p<0.05$).*

Overall, the study results indicate a high perceived value of virtual reality in Kazakhstani medical education; however, limitations related to the sample size and the subjective nature of the data must be taken into account, underscoring the need for further research to validate these findings.

Discussion.

Virtual simulation (VS) as a new interactive pedagogical strategy has been receiving increasing attention in undergraduate medical education. With the rapid advancement of modern computer-simulation technologies, an expanding range of innovative VS-based teaching approaches continues to emerge, supporting medical education in various formats. To outline current trends in VS-based medical teaching and learning, this review provides a global analysis of 92 recently published studies on the use of VS in undergraduate medical training. The findings indicate that 98% of the included articles originated from Europe, North America, and Asia, suggesting a potential imbalance in access to digital medical education. More than half (52%) of the studies reported the application of immersive VR. In recent years, VS has been widely integrated into the training of surgical procedures, emergency and pediatric emergency care, basic medical sciences instruction, radiotherapy and imaging education, training in puncture or catheterization techniques, interdisciplinary medical education, and other forms of case-based clinical training [26].

In recent years, anatomy educators worldwide have increasingly adopted advanced technologies to enhance student engagement and improve the learning experience. Prior to the COVID-19 pandemic, the integration of information and communication technologies in anatomy education was largely a matter of choice rather than necessity. However, the pandemic fundamentally shifted this paradigm: what had previously been optional rapidly became essential. Although the current epidemiological situation has stabilized—with low infection rates and high vaccination coverage—and most medical universities have resumed traditional face-to-face teaching, the availability of donor bodies remains critically low. This persistent shortage continues to constrain conventional anatomical training and, in many respects, brings the educational environment "back to where it started," reinforcing the need for sustainable technological solutions in anatomy teaching [27,28].

During the COVID-19 pandemic, emergency medicine (EM) educators were forced to employ innovative methods to ensure educational continuity. This study examined the adequacy of 360-degree video (360 video) technology in EM teaching in the context of: (a) student attitudes toward 360 video; (b) student performance on the mandatory end-of-course EM exam compared to student assessment results from the previous academic year [29].

Virtual reality technologies provide superior visualization of three-dimensional anatomical structures compared with traditional media, as they offer stereoscopic vision, a user-centered perspective, wide viewing angles, and interactive functionality [30-32]. Within such a shared, collaborative VR environment, students and instructors—regardless of their geographic location—can jointly manipulate anatomical models to support the learning objectives of the course and explore applications such as simulated surgical procedures.

In anatomical education, three-dimensional (3D) visualization technology enables active and stereoscopic exploration of anatomical structures and can be readily integrated into medical curricula alongside traditional 3D-based teaching methods [33].

The results of this study indicate that the use of VR in medical education in Kazakhstan is perceived positively by both students and instructors. Participants noted that VR significantly enhances the comprehension of complex medical concepts and the development of practical skills, which is particularly important for training future medical professionals, as traditional teaching methods are sometimes limited in their ability to model rare or high-risk situations.

Despite these limitations, the findings demonstrate that VR is a promising tool for enhancing the effectiveness of medical education in Kazakhstan. For successful integration of VR into the curriculum, it is essential to provide professional training for instructors, increase investment in technical infrastructure, and develop a strategy for gradually scaling the use of this technology. In the future, addressing these issues will help unlock the full potential of VR and significantly improve the quality of medical training.

Conclusion.

This study demonstrated the positive contribution of virtual

reality to medical education in Kazakhstan. Both instructors and students reported increased motivation, higher engagement, and improved acquisition of practical skills when using VR technologies. At the same time, several important limitations were identified, including insufficient instructor training, restricted technical infrastructure, and the subjective nature of performance evaluations, all of which warrant further investigation. The finding that 22% of participants experienced VR-induced discomfort underscores the need to develop strategies aimed at minimizing adverse effects and enhancing the effectiveness of immersive learning. Additionally, the limited sample size and short study duration highlight the necessity for broader and longitudinal research, as well as initiatives to improve the accessibility and affordability of VR technologies within Kazakhstani medical institutions. Beyond these immediate findings, the study provides a significant scientific and practical contribution to the development of medical education in Kazakhstan. It demonstrates the real potential of virtual reality as an innovative pedagogical tool and outlines the barriers and needs of both instructors and students, offering strategic directions for the modernization of educational programs. First, the results justify the need for systematic integration of VR technologies into medical training, emphasizing their effectiveness in enhancing student engagement, visualizing complex clinical processes, and enabling safe practice of procedural skills. Second, the study identifies critical areas requiring institutional attention—technical infrastructure, faculty development, and organizational support—thereby forming the basis for future national guidelines on VR implementation in medical education. Third, the findings establish a foundation for subsequent comparative research assessing the impact of VR on learning outcomes, clinical competence, student confidence, and the overall quality of simulation-based training. Taken together, this research serves as a starting point for the long-term digital transformation of medical education in Kazakhstan. It opens opportunities for the development of innovative learning modules, expansion of international collaborations, and the advancement of scientific projects in immersive educational technologies, ultimately contributing to the creation of a more effective, modern, and evidence-based medical training system.

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Резюме

ТРАНСФОРМАЦИЯ МЕДИЦИНСКОГО ОБРАЗОВАНИЯ В КАЗАХСТАНЕ: ПОТЕНЦИАЛ ВИРТУАЛЬНОЙ РЕАЛЬНОСТИ ДЛЯ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ОБУЧЕНИЯ

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Актуальность. Потенциал виртуальной реальности (VR) в медицинском образовании Казахстана оказался значительным: она предлагает инновационные методы обучения и создаёт безопасные, интерактивные тренинговые среды, способствующие освоению как теоретических знаний, так и практических навыков.

Материалы и методы. Целью данного исследования была оценка применения и эффективности виртуальной реальности в медицинском обучении на основе анкетирования 53 студентов и 20 преподавателей. Для оценки восприятия и удовлетворённости использованием VR была применена шкала от 1 до 10.

Результаты. Результаты опроса показали, что студенты отмечают существенные преимущества использования виртуальной реальности для понимания сложных медицинских концепций и отработки клинических навыков. Они высоко оценили возможность применять теоретические знания на практике, наличие качественного контента по различным дисциплинам и обеспечение безопасных условий обучения.

Заключение. Преподаватели признали виртуальную реальность ценным образовательным инструментом, однако отметили ряд проблем, включая недостаточную подготовку и ограниченный доступ к оборудованию. Устранение этих препятствий является ключевым условием успешной интеграции виртуальной реальности в образовательные программы, что позволит раскрыть её потенциал и улучшить учебные результаты.

Ключевые слова: виртуальная реальность, медицинское образование, образовательные технологии, преподаватели, студенты, инновации в образовании.

რეზიუმე

სამედიცინო განათლების ტრანსფორმაცია ყაზახეთში: ვირტუალური რეალობის პოტენციალი სწავლის ეფექტურობის გასაზრდელად

მარჟან მირზახანოვა[1], სერიკ აიაგანოვი[1], გულსარა რუსტემოვა[1], შინარ კულბაევა[1*], იური ლისიცინი[1], ჟულდიზ ტლეუბერგენოვა[1]

შ. უალიხანოვის სახელობის კოკშეტაუს უნივერსიტეტი 1, კოკშეტაუ, ყაზახეთის რესპუბლიკა

ფონური ინფორმაცია. ვირტუალური რეალობის (VR) პოტენციალი ყაზახეთში სამედიცინო განათლებაში მნიშვნელოვანი აღმოჩნდა: ის გვთავაზობს ინოვაციურ სწავლების მეთოდებს და ქმნის უსაფრთხო, ინტერაქტიულ სასწავლო გარემოს, რომელიც ხელს უწყობს როგორც თეორიული ცოდნის, ასევე პრაქტიკული უნარების შეძენას.

მასალები და მეთოდები. კვლევის მიზანი იყო ვირტუალური რეალობის გამოყენებისა და ეფექტურობის შეფასება სამედიცინო განათლებაში 53 სტუდენტისა და 20 ფაკულტეტის წევრის გამოკითხვის საფუძველზე. VR-ის გამოყენებით აღქმისა და კმაყოფილების შესაფასებლად გამოყენებული იქნა 1-დან 10-მდე შკალა.

შედეგები. გამოკითხვის შედეგებმა აჩვენა, რომ სტუდენტებმა აღნიშნეს ვირტუალური რეალობის გამოყენების მნიშვნელოვანი სარგებელი რთული სამედიცინო კონცეფციების გასაგებად და კლინიკური უნარების პრაქტიკისთვის. ისინი დიდად აფასებდნენ თეორიული ცოდნის პრაქტიკაში გამოყენების შესაძლებლობას, სხვადასხვა დისციპლინაში მაღალი

ხარისხის კონტენტის ხელმისაწვდომობას და უსაფრთხო სასწავლო გარემოს უზრუნველყოფას. დასკვნა. ფაკულტეტის წევრებმა ვირტუალური რეალობა ღირებულ საგანმანათლებლო ინსტრუმენტად აღიარეს, მაგრამ აღნიშნეს მთელი რიგი გამოწვევები, მათ შორის არასაკმარისი ტრენინგი და აღჭურვილობაზე შეზღუდული წვდომა. ამ ბარიერების გადალახვა მნიშვნელოვანია ვირტუალური რეალობის საგანმანათლებლო პროგრამებში წარმატებით ინტეგრირებისთვის, მისი პოტენციალის გამოვლენისა და სწავლის შედეგების გაუმჯობესებისთვის.

საკვანძო სიტყვები: ვირტუალური რეალობა, სამედიცინო განათლება, საგანმანათლებლო ტექნოლოგიები, ფაკულტეტი, სტუდენტები, საგანმანათლებლო ინოვაცია.