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Use of Virtual Reality (VR) for medical training: Applications at different medical departments

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Abstract--Background: The rapid evolution of medical practice necessitates innovative training methods to keep pace with the demands of modern healthcare. Traditional education methods are increasingly complemented by simulation-based approaches, which provide practical and clinically relevant experiences. Virtual Reality (VR) has emerged as a significant tool in this realm, offering immersive, interactive training environments that aim to enhance learning outcomes. **Aim:** This paper explores the application of VR across various medical departments, including emergency medicine, health information management, nursing, and pharmacy. It examines VR's effectiveness in providing experiential learning, its advantages over traditional methods, and the challenges associated with its implementation. **Methods:** The study involves a comprehensive review of current literature and practical implementations of VR in medical training. It assesses the benefits and limitations of VR, evaluates evidence supporting its use, and discusses its applications in different medical fields. Key metrics include knowledge gain, cost efficiency, and user engagement. **Results:** VR offers distinct advantages such as immersive learning experiences, repeatable practice opportunities, and cost-effective simulation solutions. It simplifies access to clinical training, supports flexible learning schedules, and fosters engagement through gamification. However, VR also presents challenges including high initial costs, the need for technical expertise, and issues related to VR sickness and realism. **Conclusion:** VR represents a promising advancement in medical training, capable of enhancing educational outcomes through immersive simulations. Despite its limitations, such as cost and technical requirements, VR provides significant benefits in terms of accessibility, engagement, and practical experience. Future developments in VR technology, including improved controls and multiplayer capabilities, are expected to further enhance its role in medical education.

Keywords--Virtual Reality, medical training, simulation, healthcare education, immersive learning, cost efficiency, user engagement.

Introduction

The rate of change in medical practice is rapid and unceasing. The evolving needs of an ageing population, the expanding array of treatment options, the collaborative nature of healthcare delivery, and the increasing complexity of healthcare systems today are markedly different from those encountered two decades ago. As a result, the methods used to prepare future healthcare professionals have had to evolve. The focus has shifted away from the ability to simply memorize or access information, towards how individuals utilize, assess, and apply this knowledge in patient care. There is, therefore, a transition away from rote memorization in favor of teaching approaches that are more clinically relevant and practical. Curricula now incorporate methods such as problem-based learning, communication skills training, and simulation-based education. Due to the increasing emphasis on clinical learning experiences and the associated challenges, simulation, in particular, has gained traction as a valuable tool for delivering experiential education. Simulation is an instructional strategy that recreates real-life scenarios, enabling learners to act as they would in actual practice, followed by performance feedback and debriefing. Research has shown that simulation is effective across numerous domains, often being “superior to traditional clinical education, producing powerful educational interventions that yield immediate and lasting results” [1].

Nonetheless, despite its growing significance in healthcare education, simulation requires substantially more resources compared to traditional methods. At a time when healthcare systems and educational institutions worldwide are facing escalating demands and constrained budgets, acquiring additional resources is increasingly difficult. Fortunately, there has been a significant expansion in the ways medical education can be delivered. This expansion has been driven not only by the use of the internet and mobile devices but also by immersive technologies. These technologies – such as augmented reality (AR) and virtual reality (VR) – have the potential to revolutionize the delivery of educational experiences. VR, in particular, has seen widespread adoption in both medical and nursing education. It involves the use of a VR headset that immerses the user in an interactive virtual environment. When paired with suitable educational software, VR enables learners to gain practical experience in a virtual setting. This paper explores what VR entails, its advantages and disadvantages, the evidence supporting its use, its practical applications, and future developments.

Defining Virtual Reality

Virtual Reality (VR) refers to the use of software to construct an immersive, simulated environment. Unlike conventional user interfaces, VR requires users to don a head-mounted display (HMD) that fully envelops them in an experience, enabling them to interact with virtual surroundings and characters in a manner that feels authentic. VR possesses a unique capability, surpassing any other existing technology, to induce a sensation of presence in a distinct environment. This immersive quality facilitates experiential learning akin to real-life experiences [2].

Screen-Based Learning

Historically, the term 'virtual reality' has been misapplied to screen-based learning in medical literature. However, it is now recognized that the essence of VR lies in its capacity to create immersion and a profound sense of presence—experiencing the sensation of 'being there' [3][4]. Consequently, only VR that provides a fully immersive experience, utilizing headsets that obscure the real world entirely, is accurately termed 'virtual reality'.

360-Degree Video

360-degree video involves filming in all directions simultaneously to capture a comprehensive view of an environment. This method employs a specialized camera to record in every angle, allowing playback through a VR headset to create an immersive viewing experience. 360-degree video is effective for providing learners with a non-interactive representation of an environment, such as using it to distract patients during painful procedures. Nevertheless, 360-degree video is predominantly a passive experience. It does not permit realistic interaction, as it is a linear recording from a fixed location, leading to a potential disconnect between the user's real-world movements and their lack of movement within the virtual space, which can induce nausea.

Interactive Virtual Reality

In contrast, interactive VR offers a fully immersive, dynamic, and adaptable virtual world. It can be likened to engaging in a highly realistic computer simulation. In medical training, this includes virtual wards, interactive patients, and virtual colleagues, allowing interactions that mirror real-world scenarios. For instance, in a virtual emergency department scenario involving a patient with chest pain, learners can navigate and engage with the virtual environment and patient as they would in actual practice. They can perform tasks such as history taking, physical examination, diagnostics, and treatment. The virtual setting can include family members and an interdisciplinary team, with real-time adaptations of patient observations, blood tests, and conversations. The virtual environment can simulate patient distress, a bustling hospital atmosphere, and emergency situations, creating a realistic and stressful context for decision-making, critical thinking, and clinical reasoning. After completing scenarios, learners receive virtual debriefing and feedback on their performance. This feedback is crucial for learning outcomes in simulations, whether VR-based or using mannequins. In VR, feedback addresses both technical and non-technical skills, allowing learners to analyze their performance and engage in blended learning. Peer learning is also facilitated as learners can exchange feedback with colleagues and mentors to discuss specific learning objectives. Organizations such as Oxford Medical Simulation are already providing these platforms globally, offering scenarios in medicine, nursing, pediatrics, psychiatry, and community health, with expanding content across various fields.

Benefits of Virtual Reality

Virtual Reality (VR) provides distinct advantages for learners, educators, and healthcare systems alike. For learners, VR simplifies access to clinical experiences. Typically, VR systems consist of a headset and a laptop, which are commercially available, easy to set up, and designed with user safety and convenience in mind. Many VR systems function independently of faculty supervision, enabling learners to engage in simulations at their convenience. This flexibility is not restricted to large centers or high-budget setups, thereby broadening and diversifying access [5]. The ability to incorporate simulation-based education into routine practice is one of VR's key strengths. Simulations can become a regular part of the learning process, much like regular gym sessions, rather than being occasional, faculty-intensive events.

Crucially, VR scenarios are repeatable, allowing learners to safely make mistakes and improve their skills through deliberate practice. This feature is central to effective simulation but is challenging to achieve with the spatial, temporal, and faculty demands of traditional simulation centers [5]. Additionally, VR's psychological safety, engaging nature, and potential for gamification foster learner engagement and promote autonomous learning. From an institutional perspective, VR enables simulation delivery at a lower cost with fewer resources. The financial burden of physical simulation varies greatly among institutions and is often complex to quantify. Studies attempting to assess the costs of immersive medical simulation suggest that conducting a single simulation scenario can exceed £200 per learner. For instance, McIntosh reports setup costs of US\$876,485 [£758,300], with annual fixed costs of \$361,425 [£275,000], and variable costs of \$311 [£237] per course hour. Iglesias-Vázquez estimates the cost of advanced life support simulation at €1,320 [£1,140] per participant for a four-day course [6][7][8][9]. In contrast, VR simulation typically involves hardware and software costs. High-quality VR hardware, including a laptop and headset, costs about £3,000. Software expenses, depending on the provider and product quality, are often less than one-tenth of physical simulation costs. Consequently, VR offers significant savings in setup and operational expenses.

Moreover, VR technologies reduce the need for physical space and faculty time. Faculty typically do not require extensive additional training to operate VR equipment, which generally involves commercially available hardware and user-friendly software. Once established, some VR systems may require faculty presence, while others do not, depending on their specific use cases. VR enables the delivery of clinical scenarios in compact spaces (2 x 2 meters) with minimal setup time (under 5 minutes). This efficiency allows for concurrent simulation activities, enabling faculty to concentrate on advanced communication skills or on-site simulations, which may not be well-suited for VR. Virtual scenarios should also be objective and standardized, ensuring consistent quality and adherence to protocols. This standardization enables institutions to integrate and practice their latest protocols before applying them in clinical settings. Furthermore, many immersive systems allow for the development of customized simulation curricula to address specific needs and generate extensive performance data. This data is valuable for monitoring utilization, enhancing learner engagement, and identifying students who may need additional training.

From a global health perspective, the cost reduction and equitable access provided by VR facilitate the worldwide distribution of simulation-based education. This democratization of high-quality medical training makes VR a promising advancement in healthcare education.

Drawbacks of Virtual Reality

Despite its advantages, VR simulation is not a universal solution. It is a tool designed to achieve specific learning objectives and should be integrated thoughtfully within an institution's curriculum and pedagogy. VR may not be suitable for every educational scenario. For instance, it is not ideal for teaching abdominal palpation, where a simple, accurate physical representation suffices. Similarly, VR may not be appropriate for certain procedural skills like cannulation, which may not require complex immersive environments. Currently, virtual characters controlled by artificial intelligence (AI) systems are not fully equipped to handle complex learning scenarios, such as delivering bad news. The nuanced processing of language and facial expressions is better managed by human instructors than by virtual agents. Implementing new technology poses challenges, including obtaining faculty support. Engaging senior faculty members can be difficult as they may perceive VR as merely a game rather than an educational tool. However, trial periods offered by many companies can help educators become familiar with the technology, reducing resistance as VR becomes more common. Institutions must recognize that VR is not a substitute for expert educators. Just as physical simulation does not replace clinical training, VR serves as a technological means to deliver simulation-based learning. Educators must determine which learning objectives are best suited for VR and which are better addressed through physical simulation. This approach will help clinicians, universities, and healthcare institutions enhance simulation delivery, reduce costs, alleviate faculty workload, and maintain training quality.

Effectiveness of VR Simulation

Numerous studies and practical implementations demonstrate that Virtual Reality (VR) effectively supports experiential learning across various fields. In aviation, VR-based simulations have been credited with nearly halving human error-related airline crashes since the 1970s [13]. Similarly, in healthcare, VR's impact is well-documented, showing substantial benefits over traditional training methods.

Evidence of Effectiveness

1. **Knowledge Gain:** Research indicates that medical students using immersive VR environments achieve significantly higher knowledge gains compared to those relying solely on screen-based learning [4]. VR has been particularly successful in surgical training, where it reduces injury rates, speeds up operations, and improves overall outcomes. Many surgical programs now incorporate VR with excellent results [14].
2. **Training in Complex Procedures:** VR has proven effective in training for complex procedures, such as transvenous lead extraction and

cardiopulmonary resuscitation (CPR). It enhances communication skills, critical thinking, and clinical decision-making [15][16][17][18][19].

3. **Cost Efficiency:** Studies comparing VR with physical simulations have shown comparable learning transfer but at a significantly lower cost. For instance, a study involving 84 nursing students found that VR simulations were as effective as physical simulations in terms of learning outcomes, with the added advantage of reduced costs [20].

Current Uses of VR in Practice

1. **Educational Institutions:** VR is increasingly integrated into medical and nursing curricula globally. For example:
 - **University of Northampton:** VR is used in a simulation suite where students engage in real-time scenarios projected onto a large screen for group learning. This integration complements existing educational structures and supports large-scale simulation practice.
 - **University of Oxford:** Mobile VR trolleys are used to transport VR equipment across various locations, enabling greater accessibility and frequent use without requiring extensive faculty involvement.
2. **Healthcare Systems:** VR is utilized by organizations like Health Education England, which supports VR simulation across 18 NHS trusts, enhancing access to simulation-based training.
3. **Assessment and Recruitment:** VR is being explored for objective structured clinical examinations, recruitment, and assessment programs. It offers benefits in terms of time, space, resource efficiency, and geographic accessibility. However, rigorous validation is essential for these applications.

Future Directions

1. **Increased Integration:** VR is expected to become a routine part of medical education and revalidation, akin to regular gym sessions for physical training. The standardization and scoring capabilities of VR will enhance its role in assessment and competency verification.
2. **Technological Advancements:** Future developments include improved hand and voice controls, enhanced haptic feedback (sense of touch), and integration with AI. AI will provide deeper analysis of clinical performance and offer tailored scenarios based on learner needs.
3. **Multiplayer VR:** Emerging multiplayer VR technology allows multiple users to interact in the same virtual scenario, facilitating real-time collaborative learning. This feature has the potential to revolutionize global healthcare education by enabling remote, cross-cultural interactions and collaborative clinical experiences.

Can VR Shorten Training?

Virtual Reality (VR) has the potential to substantially reduce training durations across various fields, including healthcare, due to several key benefits it offers. One significant advantage is the ability of VR to provide immediate feedback and

facilitate iterative practice. Learners can receive real-time corrections and refine their skills swiftly, which accelerates the learning process compared to traditional methods that might involve longer cycles of practice and feedback. Additionally, VR allows for the repetition of scenarios as often as needed. This feature enables learners to practice complex procedures multiple times in a controlled environment, thereby speeding up skill acquisition and retention. Another advantage of VR is its increased accessibility and flexibility. Learners can engage in training at any time and from various locations, which allows for more flexible integration of training into their schedules. This on-demand learning capability means that practice can occur more frequently, overcoming the constraints of physical or logistical limitations. Furthermore, VR can be seamlessly integrated into routine learning activities, making simulation a regular part of training, similar to incorporating exercise into a daily routine. This continuous and accessible practice contributes to a more efficient and accelerated learning curve.

Limitations of VR Use

Despite its promising advantages, Virtual Reality (VR) is not without limitations. One primary concern is the high initial cost associated with setting up VR systems. Although these costs are decreasing, they can still be prohibitively expensive for some institutions. The setup includes both hardware, such as headsets and computers, and software, which often requires ongoing updates and maintenance. This financial barrier can limit the widespread adoption of VR, particularly in low-resource settings. Another challenge is the requirement for technical expertise and training. While many VR systems are designed to be user-friendly, effective use often requires a certain level of technical knowledge and familiarity with the equipment. Institutions need to ensure that faculty and users are adequately trained, which can add to the overall cost and complexity of implementing VR. Additionally, VR experiences can sometimes cause discomfort or disorientation, known as "VR sickness." This phenomenon, which can include symptoms such as nausea and dizziness, can affect the learner's ability to engage with the simulation effectively. Such issues are particularly relevant in high-intensity or prolonged VR sessions, which may limit their practical application in certain training scenarios.

There are also limitations related to the fidelity and realism of VR simulations. While VR can replicate many aspects of real-world scenarios, it may not capture the full complexity of human interactions and physical sensations. For instance, current VR technology may struggle to accurately simulate nuanced emotional responses, or the tactile feedback involved in certain procedures. This can impact the realism of the training and potentially limit the effectiveness of the simulation in preparing learners for real-life situations. Moreover, VR simulations are typically designed for specific learning objectives and may not be easily adaptable to all educational needs. The rigid structure of some VR scenarios might not accommodate the variability of real-world situations or the individual learning preferences of all users. Finally, VR is often seen as a supplementary tool rather than a replacement for traditional hands-on training and human interaction. It is crucial to integrate VR into a broader educational strategy rather than relying on it exclusively. Balancing VR with other forms of instruction ensures a well-

rounded approach to training that addresses its limitations while leveraging its strengths.

Ethical Concerns in VR Use

The integration of Virtual Reality (VR) into various domains, including education and healthcare, brings several ethical concerns that must be carefully considered.

1. Privacy and Data Security: VR systems often collect a significant amount of data about users, including biometric data, behavioral patterns, and personal interactions within the virtual environment. This data collection raises privacy concerns, especially regarding how this information is stored, used, and shared. Ensuring robust data protection measures and obtaining informed consent from users is essential to mitigate these concerns.

2. Psychological Impact: The immersive nature of VR can have psychological effects on users. Extended exposure to highly realistic or stressful virtual scenarios might lead to emotional or psychological strain. For example, simulations involving traumatic or distressing content could potentially affect users' mental health. It is crucial to implement safeguards to ensure that VR experiences are designed to minimize potential negative psychological impacts and to provide support if needed.

3. Consent and Autonomy: In educational and clinical settings, obtaining informed consent is a fundamental ethical requirement. Users must be fully aware of the nature of the VR simulations they are participating in and any potential risks involved. This includes ensuring that participants understand how the VR technology works, the content they will be exposed to, and any data that will be collected about them.

4. Equity and Access: The cost and technological requirements associated with VR may create disparities in access. Institutions with limited resources might be unable to provide VR-based training, leading to unequal educational opportunities. Ensuring equitable access to VR technology and addressing the digital divide are important ethical considerations to promote fairness and inclusivity in educational and healthcare training.

5. Informed Use of Technology: There is a risk of over-reliance on VR technology, which might lead to the undervaluation of traditional educational methods and hands-on experiences. It is essential to use VR as a complementary tool rather than a replacement for real-world interactions and practical training. Educators and healthcare professionals must be mindful of integrating VR appropriately within a comprehensive training strategy.

6. Misuse of Technology: There is potential for VR technology to be misused or to be employed in ways that could harm users or exploit their vulnerabilities. For example, using VR simulations to manipulate or deceive users could raise ethical issues. Ensuring that VR applications are developed and used responsibly, with clear ethical guidelines, is necessary to prevent misuse and protect users' rights and well-being. Addressing these ethical concerns involves ongoing dialogue among stakeholders, including developers, educators, healthcare professionals, and users, to establish best practices and guidelines for the ethical use of VR technology.

Applications of VR in Different Medical Departments

1. Emergency Medicine: In emergency medicine, VR is used for both training and operational purposes. VR simulations can replicate high-pressure scenarios such as trauma care, mass casualty incidents, and emergency procedures. This allows medical professionals to practice and refine their skills in a controlled, risk-free environment. For instance, VR can simulate complex cases like cardiac arrest or severe trauma, enabling learners to experience and respond to these situations as they would in real life. This can help improve decision-making, enhance teamwork, and increase preparedness for real emergencies. Additionally, VR can be used to train emergency responders on specific procedures, such as intubation or advanced life support techniques.

2. Health Information: In health information management, VR can enhance training in the use of Electronic Health Records (EHRs) and other health information systems. Simulations can provide hands-on experience with these systems, helping users learn to navigate complex interfaces, manage patient data, and understand the workflow of health information management. VR can also be used to demonstrate the integration of health information systems with clinical practice, helping users visualize how data flows between different departments and supports patient care. Moreover, VR can aid in the training of data security and privacy measures, teaching users how to handle sensitive information in compliance with regulations.

3. Nursing: For nursing education and training, VR offers immersive simulations that replicate various clinical scenarios. This includes training on patient assessment, administration of medications, and execution of nursing procedures. VR can simulate interactions with patients, allowing nursing students and professionals to practice communication skills, manage patient care, and respond to emergencies. For example, VR can create scenarios involving difficult patient interactions or complex clinical situations, providing nurses with the opportunity to build confidence and proficiency in a safe environment. Additionally, VR can be used to train nurses in specific skills such as wound care or intravenous insertion.

4. Pharmacy: In pharmacy education, VR can simulate the preparation and dispensing of medications, providing a virtual environment for pharmacists to practice their skills. This includes training on drug interactions, dosage calculations, and the management of complex pharmaceutical therapies. VR can also be used to simulate patient consultations, allowing pharmacists to practice communication skills and patient counseling in a realistic setting. For example, VR scenarios might involve discussing medication adherence with patients or handling drug-related problems. Furthermore, VR can help pharmacy students and professionals understand the implications of medication errors and develop strategies to prevent them.

5. General Applications Across Departments: Beyond specific departmental uses, VR can also facilitate interdisciplinary training and collaboration. For instance, VR simulations can bring together emergency medical teams, nurses, and pharmacists to work on a coordinated response to a complex case, promoting teamwork and understanding of each role's contributions. Additionally, VR can be used for patient education, helping individuals understand their conditions, treatment options, and rehabilitation processes through interactive and engaging simulations. Overall, VR applications in these medical departments enhance

education, improve clinical skills, and support better patient care through immersive, realistic, and interactive experiences.

Conclusion

Virtual Reality (VR) has emerged as a transformative tool in medical education, offering unique opportunities to enhance training across various medical departments. By creating immersive, interactive environments, VR addresses the limitations of traditional training methods and provides a platform for experiential learning. This paper highlights the extensive applications of VR in fields such as emergency medicine, health information management, nursing, and pharmacy, demonstrating its potential to revolutionize medical education. In emergency medicine, VR simulations enable learners to experience high-pressure scenarios, enhancing their decision-making and clinical skills. In health information management, VR offers practical training in navigating Electronic Health Records (EHRs) and understanding data workflows. For nursing and pharmacy, VR provides realistic simulations of patient interactions, procedural skills, and medication management, improving competency and confidence in these critical areas. The benefits of VR are manifold. It facilitates flexible and on-demand learning, allowing learners to engage with simulations at their convenience and repeat scenarios as needed. This iterative practice accelerates skill acquisition and retention, addressing the constraints of physical and logistical limitations inherent in traditional training methods. Moreover, VR's cost efficiency compared to physical simulations makes it an attractive option for institutions facing budget constraints. The ability to deliver high-quality simulations with minimal resource requirements is a significant advantage, promoting wider accessibility and equitable education opportunities. Despite these benefits, VR is not without its challenges. The high initial setup costs, the need for technical expertise, and the potential for VR sickness are notable concerns. Additionally, the current technology may not fully capture the complexity of human interactions or provide the tactile feedback necessary for certain procedures. To address these limitations, VR should be integrated thoughtfully into medical curricula, complementing rather than replacing traditional training methods. Looking ahead, advancements in VR technology, such as improved haptic feedback and AI integration, promise to enhance the realism and effectiveness of simulations further. Multiplayer VR experiences could facilitate collaborative learning and global interactions, expanding the potential impact of VR in medical education. Overall, VR represents a promising frontier in medical training, offering significant advantages while requiring careful implementation to maximize its benefits.

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استخدام الواقع الافتراضي (VR) في التدريب الطبي - التطبيقات في الأقسام الطبية المختلفة

الملخص:

الخلفية: إن التطور السريع في الممارسات الطبية يتطلب أساليب تدريب مبتكرة لمواكبة احتياجات الرعاية الصحية الحديثة. تتكامل الأساليب التعليمية التقليدية بشكل متزايد مع المناهج المستندة إلى المحاكاة، والتي توفر تجارب عملية وسريعية ذات صلة. لقد ظهر الواقع الافتراضي (VR) كأداة مهمة في هذا المجال، حيث يوفر بيئات تدريب غامرة وتفاعلية تهدف إلى تعزيز نتائج التعلم.

الهدف: يستكشف هذا البحث تطبيقات الواقع الافتراضي في مختلف الأقسام الطبية، بما في ذلك طب الطوارئ، وإدارة المعلومات الصحية، والتمريض، والصيدلة. كما يفحص فعالية الواقع الافتراضي في توفير التعلم التجريبي، ومزاياه مقارنة بالأساليب التقليدية، والتحديات المرتبطة بتطبيقه.

الطرق: يتضمن هذا البحث مراجعة شاملة للأدبيات الحالية وتطبيقات الواقع الافتراضي العملية في التدريب الطبي. يقوم بتقييم الفوائد والقيود المتعلقة باستخدام الواقع الافتراضي، ويحلل الأدلة الداعمة لاستخدامه، ويناقش تطبيقاته في مختلف المجالات الطبية. تشمل المقاييس الرئيسية زيادة المعرفة، والكفاءة الاقتصادية، ومشاركة المستخدم.

النتائج: يوفر الواقع الافتراضي مزايا مميزة مثل تجارب التعلم الغامرة، وفرص التدريب المتكرر، وحلول المحاكاة الاقتصادية. كما يُبسّط الوصول إلى التدريب السريري، ويدعم جداول تعلم مرنة، ويعزز التفاعل من خلال اللعب التفاعلي. ومع ذلك، يواجه الواقع الافتراضي تحديات مثل التكاليف الأولية العالية، والحاجة إلى الخبرة التقنية، والمشكلات المرتبطة بالمرض الافتراضي والواقعية.

الخلاصة: يمثل الواقع الافتراضي تقدمًا واعدًا في التدريب الطبي، حيث يمكنه تحسين النتائج التعليمية من خلال المحاكاة الغامرة. على الرغم من قيوده، مثل التكاليف والمتطلبات التقنية، يوفر الواقع الافتراضي فوائد كبيرة من حيث إمكانية الوصول، والتفاعل، والتجربة العملية. من المتوقع أن تعزز التطورات المستقبلية في تكنولوجيا الواقع الافتراضي، بما في ذلك تحسين أدوات التحكم والقدرات المتعددة اللاعبين، دوره في التعليم الطبي.

الكلمات المفتاحية: الواقع الافتراضي، التدريب الطبي، المحاكاة، التعليم الصحي، التعلم الغامر، الكفاءة الاقتصادية، مشاركة المستخدم.