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Use of real-time graphics in health education: A systematic review

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Abstract

Introduction: Using real-time graphics in health education is particularly relevant in technical skill development and knowledge acquisition in surgery, emergency medicine, and nursing.
Objective: To systematize the literature on using real-time graphics in health education.
Methods: A systematic review was conducted in the databases: PubMed, Scopus, Embase, Web of Science, Cochrane Library, CINAHL, and ERIC.
Results: The impact of real-time graphics use, including virtual reality (VR), in health education was examined, covering disciplines such as medicine, nursing, and other related professions. The findings of the selected studies for this review and existing literature suggest that implementing real-time graphics technologies in health education can significantly improve learning and the acquisition of clinical skills compared to traditional approaches.
Conclusions: Virtual reality was found to be particularly effective in training technical skills and surgical procedures and improving the quality of teaching in various disciplines. These findings support experiential learning theory and the idea that repeated practice and immediate feedback in a safe and controlled environment are essential for skill acquisition.

Keywords: real-time graphics, virtual reality, augmented reality, higher education in health, nursing, health informatics

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1. Introduction

Health education is critical for developing highly trained and competent professionals capable of providing quality health care to patients and communities. [1] Health education has undergone considerable transformation in recent years due to technological advances and the growing need to adapt to demographic and epidemiological changes. [2] One of the most promising innovations in this field is the use of real-time graphics and augmented and virtual reality technologies, which have been shown to impact health education's quality and effectiveness significantly. [3,4]
Real-time graphics, including virtual reality (VR), augmented reality (AR), and simulation, allow students and healthcare professionals to immerse themselves in virtual environments and engage in hands-on, interactive learning experiences. [5–7] These technologies allow students to

practice medical skills and techniques in a safe and controlled environment, enabling immediate feedback and continuous improvement in clinical skills. [8–10]

The use of real-time graphics in health education is especially relevant in training technical skills and knowledge acquisition in areas such as surgery, emergency medicine, and nursing. [11–13] In these specialities, performing procedures and making clinical decisions effectively and safely is critical to ensuring optimal patient outcomes. Real-time graphics allow students to practice and refine these skills without jeopardizing the lives and well-being of actual patients. [14,15]

The importance of using real-time graphics in health education has become increasingly evident in the scientific literature. Numerous studies have shown that these technologies can enhance knowledge and skill acquisition, increase student confidence and satisfaction, and ultimately improve patient outcomes. [16–18] Specifically, virtual reality and computer-based simulations. Computers have proven to be practical tools for training in laparoscopic surgery, resulting in improved surgical performance and decreased postoperative complication rates. [19–21]

In addition to improving the quality of health education, using real-time graphics can also address some of the limitations and challenges inherent in traditional teaching approaches. For example, teaching models based on observation and practice in actual clinical settings are often limited by the availability of suitable cases and patients for learning. Furthermore, these approaches may not allow for student-centred and individualized learning. [22,23]

Real-time graphics and virtual and augmented reality technologies allow for greater flexibility and adaptability in teaching and learning, ensuring that students can learn and master specific clinical skills at their own pace and time. [22,24] Real-time graphics can foster interprofessional education, encouraging collaboration and communication between students and professionals from various health disciplines, such as medicine, nursing, kinesiology, radiology, and clinical laboratory. [25]

Interprofessional education is essential to improve the coordination and quality of health care, as it allows professionals to understand and value the skills and competencies of their colleagues in other specialities. [26]

Virtual environments and simulations can provide unique opportunities for students from different disciplines to work together in realistic clinical scenarios, fostering collaboration and teamwork. [27,28]

Despite the advances and promise of real-time graphics in health education, it is also essential to recognize the limitations and challenges of implementing these technologies. The cost and infrastructure required to develop and implement virtual and augmented reality solutions can be prohibitive for some healthcare and educational institutions. Furthermore, the effectiveness of real-time graphs may vary depending on the quality of the design and implementation of educational interventions and the individual characteristics of students and professionals.

Despite these challenges, using real-time graphics in health education can transform how the next generation of health professionals are trained.[29–31] By providing opportunities to learn and practice clinical skills in safe and controlled environments, these technologies can improve the quality of healthcare education and ultimately contribute to better outcomes for patients and communities. As research and practice in this field continue to evolve, educators, researchers, and policymakers must collaborate to take full advantage of the opportunities offered by real-time graphics and address challenges that may arise along the way. This review aims to systematize the literature using real-time graphics in health education.

2. Methods

Type of study: Systematic review.

Search strategy: The search will use keywords and search terms related to real-time graphics, health education and specific specialities (medicine, nursing, kinesiology, radiology, clinical laboratory, etc.). Boolean operators (AND, OR) and parentheses will combine search terms and refine the results.

Search strategy: The following search strategy was used and adjusted according to the database in question: (real-time graphics OR virtual reality OR augmented reality OR simulation) AND (health education OR medical education OR nursing education OR kinesiology education OR radiology education OR clinical laboratory education) AND (effectiveness OR impact OR outcome).

Consulted databases: The following databases were searched: PubMed, Scopus, Embase, Web of Science, Cochrane Library, CINAHL, and ERIC.

Inclusion criteria:

- Studies that evaluate the use of graphics in real-time in education in health.
- Studies published in English or Spanish.
- Primary research studies include randomized controlled trials, quasi-experimental studies, or cohort studies.
- Studies that provide quantitative data on the effect of real-time graphics in health education.

Exclusion criteria:

- Studies not related to education in the area of health.
- Studies that do not evaluate the use of real-time graphics or similar technologies.
- Case studies, case series and qualitative studies.
- Studies that do not provide quantitative data on the effect of real-time graphics on health education.
- Studies published in languages other than English or Spanish.

The selection process of the articles included:

For the articles' selection, the PRISMA methodology was followed 20. The stages of the process are shown in Table 1.

Table 1. Flowchart of selection of the articles included in the review.

Stage	Articles
Articles identified in the initial search	1050
Articles excluded after reviewing titles and abstracts	975
Full-text articles evaluated	75
Articles excluded after evaluating the full text	68
Articles finally included in the systematic review and meta-analysis	7

3. Results and Discussion

Table 1 includes the type of study, the sample size, the intervention, the speciality, the measured effect, the main conclusions and the reference of the included studies. This systematic review examined the impact of real-time graphics, including virtual reality (VR), in healthcare education, spanning medicine, nursing, and related professions. The findings of the studies selected for this review and the existing literature suggest that implementing real-time graphics technologies in health education can significantly improve learning and the acquisition of clinical skills compared to traditional approaches.

The studies by Wong *et al.* (2018) [32] and Alaker *et al.* (2016) [33] showed that VR is effective in medical and nursing education, especially in technical training skills and surgical procedures. These findings support Kolb's experiential learning theory, which holds that repeated practice and immediate feedback in a safe and controlled environment are critical to skill acquisition. [34]

The review results by McGaghie *et al.* (2011) [35] also support this theory since they found that medical education based on simulations with deliberate practice produces better results than traditional clinical education.

In line with these findings, Kyaw *et al.* (2019) conducted a systematic review and meta-analysis that concluded that VR is an effective tool for improving health professions education compared to traditional methods. [36] In addition, the research by Cipriano *et al.* (2013) [37] and Pottle (2019) [38] suggest that implementing online and VR technologies in medical education can significantly improve the quality of teaching and learning in various disciplines, including dermatology. These results support the idea that emerging technologies such as VR have the potential to revolutionize healthcare education. [39–42]

The review by Frenk *et al.* (2010) [43] highlights the importance of the transformation of education in the health area to address the current and future challenges of the health system. Real-time graphics and VR play a critical role in this transformation, as they can provide more personalized and adaptive learning, foster interprofessional collaboration, and enable the practice of clinical skills in safe and controlled environments. In this context, implementing real-time graphics technologies in health education can improve the quality of care and patient outcomes.

Despite the promising findings of the studies included in this review, it is also essential to recognize the limitations and challenges of implementing real-time graphics and VR in health education. [44,45] For example, the cost and infrastructure required to develop and implement VR solutions can be prohibitively expensive for some institutions. Furthermore, the effectiveness of real-time graphics and VR may vary depending on the quality of the design and implementation of educational interventions and the individual characteristics of students and professionals. Therefore, educators and researchers must work together to develop evidence-based approaches that maximize the potential of these technologies.

Another limitation of this systematic review is the heterogeneity in the included studies regarding methodology, student populations, disciplines, and technologies used. This variability makes it difficult to directly compare the results and generalize the findings to different settings and populations. Furthermore, although most of the studies in this review reported positive outcomes related to implementing real-time graphics and VR in health education, some studies may have been excluded due to the inclusion and exclusion criteria used. Therefore, the review may not have captured all relevant studies in this field.

Regarding the implications for future research, it would be helpful to carry out additional studies evaluating the long-term impact of the implementation of real-time graphics and VR in health education, as well as studies exploring how these technologies can be used more effectively in different contexts and disciplines. Future studies could address the barriers and facilitators of real-time graphics and VR implementation in health education, including student and professional acceptance, costs, and infrastructure.

4. Conclusions

The findings of this systematic review suggest that real-time graphics and VR have significant potential to improve healthcare education in terms of clinical skills acquisition, learning, and student satisfaction. The studies included in this review showed that virtual reality and other real-time graphics technologies could improve learning compared to traditional teaching and clinical practice methods.

Virtual reality is especially effective in technical training skills and surgical procedures, as well as in improving the quality of teaching in various disciplines. [46,47] These findings support experiential learning theory and the idea

that repeated practice and immediate feedback in a safe and controlled environment are critical to skill acquisition. [48]

Implementing real-time graphics technologies in health education can improve the quality of care and patient outcomes. The transformation of education in health is crucial to address health systems' current and future challenges. The adoption of emerging technologies, such as virtual reality, can provide more personalized and adaptive learning, foster interprofessional collaboration, and enable the practice of clinical skills in safe and controlled environments.

However, it is important to recognize the limitations and challenges associated with implementing real-time graphics and virtual reality in health education, such as cost, infrastructure, and variability in the quality of the design and implementation of educational interventions. [49]

As research and practice in this field continue to evolve, educators, researchers, and policymakers must collaborate to maximize the opportunities offered by real-time graphics and virtual reality and to address the challenges that may arise in the process. [50]

It is essential to highlight that future research evaluating the long-term impact of implementing real-time graphics and virtual reality in health education and exploring how these technologies can be used effectively in different contexts and disciplines.

Ultimately, adopting real-time graphics and virtual reality in healthcare education can transform how healthcare professionals learn and acquire clinical skills, resulting in better care. Higher quality healthcare and better patient outcomes. This systematic review provides a solid foundation for future research and development in this field and underscores the importance of exploring and adopting emerging technologies in health education.

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