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The promotion and development of VR education in Chongqing medical education

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Abstract: This study aims to evaluate the effectiveness and impact of virtual reality technology in the context of medical education in Chongqing. The research examines how VR influences students' development of practical skills, retention of anatomical knowledge, learning efficiency, and overall satisfaction. A mixed-methods approach was adopted, integrating both quantitative and qualitative research methods. Quantitative data were collected through structured questionnaires measuring test scores, cognitive load, and satisfaction levels among medical students. Qualitative insights were gathered through in-depth interviews with students and faculty to understand their experiences, perceptions, and recommendations regarding the use of VR technology in education. The results reveal that students using VR technology demonstrated significantly improved performance in anatomy-related courses and higher engagement levels compared to those taught through traditional methods. Moreover, the study found that appropriate training and technical support are essential for maximizing the benefits of VR technology, as they help reduce cognitive load and enhance learning outcomes. The findings also indicate that the effectiveness of VR is influenced by its perceived usefulness and ease of use, aligning with the principles of the technology acceptance model. The study concludes by recommending best practices for integrating VR into medical curricula, including gradual implementation, development of diverse and high-quality VR content, and continuous evaluation of its effectiveness. These findings provide valuable insights for educators and policymakers seeking to leverage VR technology to enhance medical training and improve student learning outcomes.

Key words: virtual reality; medical education; learning efficiency; student satisfaction; constructivist learning theory

1 Introduction

1.1 Background

VR education in Chongqing began in 2015, which was initially used in subjects like science and geography at schools such as Chongqing Experimental Foreign Language School. With technological advancements and increased government investment, VR use expanded significantly. By 2021, it was widely implemented, with Chongqing Normal University, Chongqing University, and Chongqing Medical University leading the way in research and integration of VR in medical training through virtual operating rooms and simulations [1].

1.2 Research gaps

Although progress has been made in virtual reality education, research on its acceptance and effectiveness remains limited. There is a lack of detailed data on factors influencing adoption across subjects and grade levels, and existing VR

content is not versatile enough, highlighting the need for further research [2].

1.3 Research objectives and questions

This study aims to address these gaps, particularly in medical education:

Objective 1: evaluate VR's impact on skill development.

Research question: How does VR influence surgical skills, knowledge retention, and problem-solving compared to traditional methods?

Objective 2: assess VR's effect on empathy and communication skills in training.

Research question: How does VR improve empathy and communication skills when interacting with patients?

Objective 3: identify best practices for integrating VR into curricula.

Research question: What are the best practices for integrating VR to enhance learning outcomes and ensure sustainability?

2 Literature review

2.1 Theoretical framework

2.1.1 Constructivist learning theory

Constructivist theory emphasizes learning through active interaction with the environment. In VR medical education, virtual labs allow students to practice surgical procedures, reducing resource waste and risks [3].

2.1.2 Technology acceptance model (TAM)

TAM assesses technology acceptance based on perceived usefulness (PU) and perceived ease of use (PEOU). In VR medical education, TAM highlights the benefits of VR for skill enhancement and promotes ease of use through training and user-friendly interfaces [4].

2.1.3 Diffusion of innovations theory

DOI explains how new technologies spread. Sharing successful VR applications through seminars and journals, along with phased implementation, can expand VR use in medical education.

2.2 History research

Chongqing Medical University's VR operating rooms have enhanced student skills and knowledge retention. A 2021 meta-analysis revealed that VR improved test scores and student satisfaction in anatomy learning compared to traditional methods [5].

2.3 Challenges

Challenges for VR adoption in Chongqing include low awareness, limited technical expertise, and high equipment costs, which hinder large-scale implementation [6].

3 Methodology

3.1 Conceptual framework

Objective: explore the impact of VR technology on anatomy teaching in Chongqing's medical education.

3.1.1 Independent variables

VR technology application: use of VR tools and simulations in anatomy teaching.

Traditional teaching methods: lectures, textbooks, and autopsies.

3.1.2 Conditioning variables (CVs):

Cognitive load: mental effort required for using VR technology.

Training and assistance: support provided to students and teachers for using VR.

3.1.3 Dependent variables (DVs)

Exam results: performance differences in anatomy exams.

Student satisfaction: engagement and contentment with the teaching method.

Learning efficiency: memory retention and speed of acquiring anatomical knowledge [7].

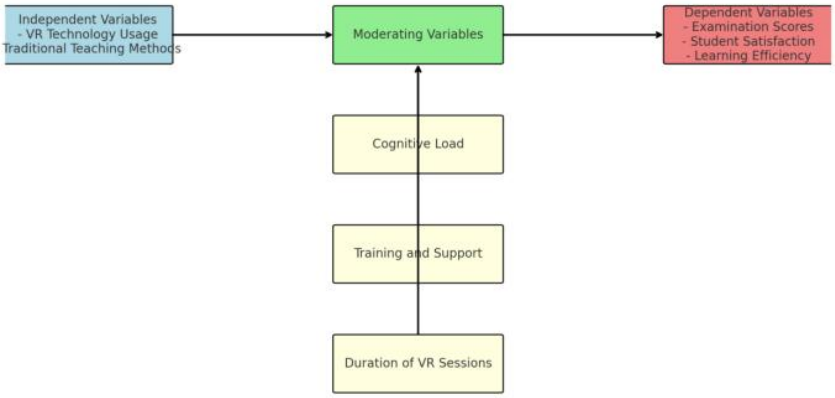

Figure 1. Conceptual framework

3.2 Research hypothesis

Research hypothesis 1

Hypothesis: Students using VR technology for anatomy will achieve higher test scores compared to traditional methods.

Independent variable: teaching method (VR vs. Traditional methods); Dependent variable: test score

Research hypothesis 2

Hypothesis: Proper training and support can reduce cognitive load, improving learning efficiency and satisfaction.

Independent variable: level of training and support; Moderator variable: cognitive load

Dependent variables: learning efficiency and student satisfaction

Research hypothesis 3

Hypothesis: A shorter VR course duration can reduce cognitive load and enhance learning outcomes.

Independent variable: duration of VR course; Moderator variable: cognitive load

Dependent variable: learning outcomes (including test scores and learning efficiency)

3.3 Research design

3.3.1 Mixed-methods approach

Quantitative and qualitative methods are combined for a comprehensive evaluation of VR's impact on medical education.

3.3.2 Study design

Questionnaire: collect data on satisfaction, cognitive load, and learning effects.

Test scores: compare VR and traditional teaching performance.

Statistical analysis: use SPSS for descriptive statistics, t-tests, and regression analysis.

3.4 Sampling

3.4.1 Quantitative sampling

Stratified random sampling ensures representativeness based on academic year and gender.

3.4.2 Quantitative sampling

Evaluates VR's impact on 322 students from a population of 2,000 medical students (95% confidence level, 5% margin of error).

$$n = \frac{N \cdot Z^2 \cdot p \cdot (1-p)}{E^2 \cdot (N-1) + Z^2 \cdot p \cdot (1-p)}$$

Figure 2. Sample size formula for finite populations

Among them:

n = sample size

N = population size (2,000)

Z = Z-score (1.96 at 95% confidence level)

p = assumed proportion (generally 0.5)

E = error range (0.05)

The required sample size was calculated to be 322. A complete list of medical students at Chongqing Medical University was obtained, and random IDs were selected using software like Excel or R. Data were analyzed using SPSS or R for descriptive and inferential statistics, including t-tests and regression analysis.

3.5 Instrument

3.5.1 Questionnaire

The questionnaire assessed the impact of VR technology on Chongqing medical education, covering:

Basic information: gender, age, grade, professional direction, VR usage experience;

VR usage: satisfaction, learning interest, efficiency, concentration;

Learning effect: changes in learning efficiency and test scores after using VR;

User experience: ease of use, physical discomfort, and feedback;

Open questions: suggestions for improving VR in medical education.

3.5.2 Interview

Interviews with students and teachers focused on learning outcomes, skill development, engagement, technical challenges, and overall evaluation. Each interview lasted for 30-45 minutes [8].

3.6 Data collection

3.6.1 Preparation for data collection

A detailed data collection schedule was established, and random sampling was used to ensure representativeness. All data were securely recorded and backed up.

3.6.2 Data management and analysis

Data were analyzed using SPSS or R, including descriptive and inferential statistics. Regular backups were maintained.

3.7 Qualitative data analysis

Interview transcripts were coded line-by-line to identify key themes like "learning enhancement" and "interest improvement", which were grouped into broader categories such as "learning effect" for organized analysis.

4 Research Results

4.1 Quantitative analysis results

After analyzing the questionnaire responses from 322 medical students, the following key findings were identified:

Knowledge retention and learning efficiency: Students who utilized VR-based instruction in anatomy demonstrated an average test score of 85, significantly higher than the average score of 78 achieved by students in traditional instruction settings ($p < 0.01$). This suggests that VR technology offers notable advantages in enhancing students' knowledge retention

and learning efficiency.

Student satisfaction: The survey results indicated that 83% of students reported feeling "very satisfied" or "satisfied" with VR-based learning. Comparatively, traditional instruction methods received a satisfaction rate of only 60%, underscoring the positive reception and engagement of VR technology in medical education.

Cognitive load reduction: VR training with structured support led to a measurable reduction in cognitive load. Students receiving guidance and technical assistance with VR reported a lower cognitive load (mean score of 3.2 on a 5-point scale) than those who engaged with VR independently (mean score of 4.1). This emphasizes the role of technical support in optimizing VR learning outcomes by reducing mental effort.

4.2 Qualitative analysis results

Qualitative insights were gathered through in-depth interviews with students and faculty, revealing several themes:

Enhanced practical skills: Students expressed that VR simulations, particularly in virtual operating rooms, provided a safe and realistic environment for developing practical skills. They reported greater confidence in surgical procedures and noted that compared to textbooks or lectures, VR offered a more hands-on approach.

Increased engagement and motivation: Both students and faculty noted VR's immersive quality as a key factor in enhancing engagement. Students found VR learning to be highly stimulating and interactive, which fostered a stronger motivation of students to learn complex material, and perform anatomy and procedural tasks.

Challenges in implementation: Despite the benefits, students highlighted challenges, including occasional dizziness and discomfort, especially during longer VR sessions. Faculty noted the high initial setup costs and the need for technical expertise to effectively integrate VR into the curriculum, suggesting the necessity of additional resources for widespread adoption.

5 Conclusion

This study demonstrates that VR technology significantly enhances knowledge retention, skill development, and student satisfaction in Chongqing's medical education. By providing immersive, interactive experiences, VR contributes to a more hands-on learning approach, surpassing traditional methods in student engagement and educational outcomes. However, effective implementation requires dedicated support and training to mitigate cognitive load and ensure positive experiences for users. Addressing the technical and financial challenges associated with VR adoption will be essential for sustainable integration. These findings provide actionable insights for educators and policymakers aiming to leverage VR technology to elevate medical training quality and efficacy. Future research may further explore VR's long-term impacts on professional competence and its scalability across diverse medical fields.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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