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Virtual Reality as an Interactive Method for Anatomy Education

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ABSTRACT

In the field of anatomy education, Conventional teaching methods often lack the immersive experience necessary for a comprehensive understanding of the human body. However, the introduction of Virtual Reality (VR) technology has brought about an innovative approach that holds the potential to revolutionize anatomy education. This article explores the use of VR as an interactive and immersive method for anatomy education, wherein students can explore and study the human anatomy in a lifelike virtual environment. The proposed method involves using VR headsets, enabling students to navigate through body systems, dissect virtual organs, and view structures from various angles. Implementation scenarios include guided sessions, where the teacher wears a VR headset, and students observe the dissection and explanation on a connected monitor, facilitating participation for large groups. Independent exploration is another option, where each student wears an individual VR headset and explores the virtual anatomy independently. Additionally, real-time collaborative learning brings both the teacher and students into the same virtual environment, encouraging active engagement and in-depth discussions. Although challenges like setup costs and accurate representation of anatomy exist, the future of VR in anatomy education looks promising.

Keywords: Virtual Reality, Anatomy, Education, Technology, Interactive

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1. Introduction

Anatomy education is vital for healthcare professionals to comprehend the intricacies of the human body. 3D perception of human body structures has a special importance in learning anatomy. Although dissection being a perfect means to understand human body in 3D dimensions, it is not enough for learning all aspects of it **(1)**. Conventional methods like anatomical models and prossection dissections lack interactivity and fail to engage students effectively. Nevertheless, the emergence of virtual reality (VR) technology presents a promising solution to improve anatomy education by providing immersive and interactive learning experiences **(2)**. VR is an immersive technology that creates computer-generated environments, allowing users to interact with digital content in three-dimensional

space (3). When used in anatomy education, it offers transformative learning experiences by placing students at the center of the process. VR enables interactive and intuitive engagement with anatomical structures, surpassing the limitations of Conventional methods (3, 4). It allows students to visualize anatomical structures in three dimensions, providing a comprehensive understanding of the subject matter. This immersive experience enhances spatial awareness and fosters a deeper appreciation for the complexities of the human body (5).

VR in anatomy education not only allows for visualizing anatomical structures but also provides interactive and hands-on learning experiences. VR platforms include interactive simulations and virtual dissections, enabling students to actively manipulate virtual objects and practice procedures in realistic scenarios (6). This immersive learning in a risk-free environment helps students acquire essential skills and understand anatomical relationships (7). Furthermore, it addresses limitations of Conventional methods like cadaver dissections, which can be limited in availability and pose ethical and emotional challenges (8). VR offers a scalable and accessible alternative, allowing students to explore anatomy without physical specimens. It accommodates a larger number of students simultaneously, fostering collaboration and active learning in the same virtual environment (8, 9).

This article explores the innovative use of VR as an interactive and immersive method for anatomy education. The method involves utilizing VR headsets to create a lifelike virtual environment that students can explore, dissect, and study the intricacies of the human anatomy in a hands-on and engaging manner. This approach allows educators to provide a more comprehensive and dynamic learning experience, enhancing student's understanding of the human body like never before.

2. Protocol

We used VR as an interactive tool for anatomy education in several key steps.

2-1- VR Content Development

The first step in implementing VR as an interactive method for anatomy education is to develop high-quality VR content. This content serves as the foundation of the virtual environment in which students will learn and explore the human body. The development process involves a team of experts, including anatomists, medical professionals, 3D artists, and software developers.

a. Anatomical Data Collection: Accurate anatomical data is essential for creating realistic virtual models. This data can be sourced from medical imaging techniques such as MRI (Magnetic Resonance Imaging) and CT (Computed Tomography) scans. Ethical considerations must be taken into account when using such data, ensuring patient privacy and consent.

b. 3D Modeling: Skilled 3D artists use the anatomical data to create detailed virtual models of organs, tissues, bones, and other structures. The models should accurately represent the size, shape, and relationships of the anatomical elements.

c. Interactive Features: The VR content should include interactive features that allow students to manipulate and examine the virtual anatomy. This may involve the ability to rotate, zoom in, zoom out, and dissect virtual organs and systems.

d. Realistic Textures and Rendering: To enhance the immersive experience, realistic textures and high-quality rendering techniques are applied to the 3D models, creating a lifelike virtual environment.

2-2- VR Hardware Setup

The next step is to set up the necessary hardware for both the teacher and students to access the VR content.

a. VR Headsets: High-quality VR headsets are crucial for an immersive anatomy education experience. These headsets should have high resolution, a wide field of view, and low latency to reduce motion sickness. Among the available options, the Oculus Quest 2 stands out for its high-resolution display and wide field of view, delivering a realistic and immersive experience (which we use this headset). The HTC Vive is another popular choice, offering motion controllers for interactive exploration of virtual anatomy. For wireless and standalone convenience, the Oculus Quest series provides portability and ease of use (10).

b. VR-Ready Computers: The computers used to run the VR content must be powerful enough to handle the complex graphics and processing requirements. They should meet or exceed the recommended system requirements for the VR headsets.

c. Monitors: In scenarios where the teacher guides students from a monitor, a large display screen is needed to ensure clear visibility for all students.

d. Tracking Devices: For scenarios where the teacher and students share the same virtual environment, tracking devices such as motion controllers or external sensors are necessary to

accurately capture movements and interactions. The oculus quest systems has this tracking devices in it.

2-3- Implementation Scenarios

The interactive method for anatomy education using VR offers multiple implementation scenarios to cater to different teaching styles and class sizes.

a. Guided Sessions: In this scenario, the teacher wears the VR headset to demonstrate and teach anatomy to the students. The teacher can interact with virtual organs, manipulate anatomical structures, and perform dissections while the students observe on a large screen or monitor. This arrangement allows a large number of students to participate simultaneously and learn from the teacher's expertise in a systematic and organized manner. Guided sessions effectively introduce students to VR-based anatomy education, showcasing its potential and enhancing their learning experience. Moreover, it encourages a collaborative learning environment, enabling interactions between students and the teacher, fostering discussions and knowledge sharing (Figure 1).

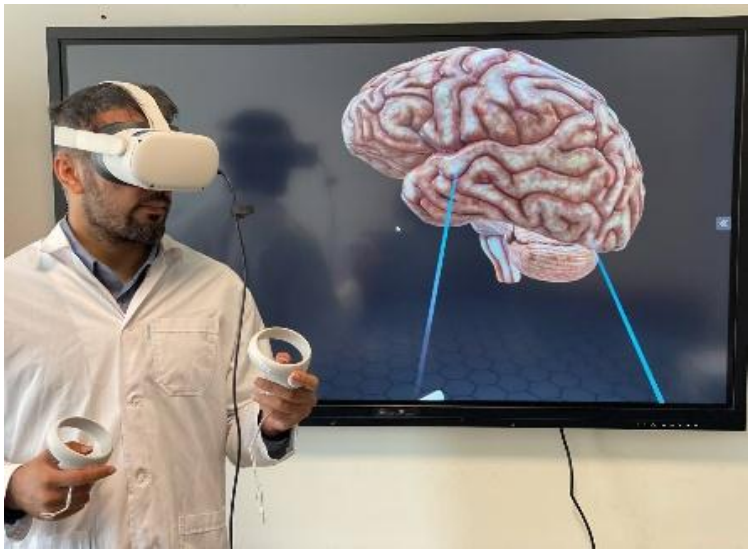

Figure 1. Guided sessions scenario (Design by Authors, 2024)

b. Independent Exploration: In this scenario, students are given individual VR headsets, allowing them to explore the virtual anatomy independently and at their own pace. They can navigate the human body, zoom in on organs, and engage in virtual dissections for a comprehensive understanding. While students explore, the teacher monitors their progress from a separate screen, providing real-time assistance when needed. This scenario nurtures self-directed learning, critical thinking, and problem-solving skills. Students take ownership of their learning journey, catering to different learning styles and paces. This autonomy empowers them to become proactive learners, preparing them for success in the medical field (Figure 2).

c. Real-time Collaborative Learning: For smaller groups, both the teacher and students can wear VR headsets simultaneously, entering the same virtual environment. Real-time collaborative learning in VR-based anatomy education involves both the teacher and students wearing VR headsets simultaneously, sharing the same virtual environment. The teacher creates a virtual classroom within the anatomy application, leading live demonstrations and interactive lessons. Students observe the teacher's actions and explanations in real-time, fostering active participation and engagement. They can ask questions, interact with the virtual anatomy, and engage in discussions with peers and the teacher. This collaborative approach cultivates camaraderie, teamwork, and critical thinking. The immersive VR environment enhances the learning experience, preparing students for success in their medical education and future healthcare practices through the innovative power of VR (Figure 3).

2-4- Assessment and Feedback

To gauge the effectiveness of using VR as an interactive method for anatomy education, assessment and feedback mechanisms are essential.

a. Assessment Tools: Quizzes, interactive assessments, and practical exercises within the VR environment can be designed to evaluate students' understanding of the anatomy.

b. Student Feedback: Gathering feedback from students about their experiences with the VR-based method can provide valuable insights for further improvement and refinement.

Figure 2. Independent Exploration scenario (Design by Authors, 2024)

Figure 3. Independent Exploration scenario (Design by Authors, 2024)

3. Results and Discussion

Three distinct scenarios have been successfully implemented in the context of virtual reality (VR) anatomy education. These scenarios harness the immersive potential of VR technology to revolutionize the way students engage with and comprehend anatomical concepts. Collectively, these scenarios underscore the versatility and effectiveness of using VR technology for anatomy education. Each approach addresses different learning styles and preferences, catering to a diverse range of students. This diversity in implementation scenarios showcases the adaptability of VR in education, suggesting a promising future for immersive, and dynamic anatomical learning experiences **(11-15)**. It is

essential to note that the new means of anatomy education will not completely exempt the need of cadaver dissection, since in teaching through cadaver, professionalism will be taught as well as 3D perception **(16)**.

The scenarios facilitating real-time interaction and collaboration between the teacher and students in VR-based anatomy education have shown great effectiveness **(17)**. When both wear VR headsets and share the same virtual environment, students receive live demonstrations and explanations from the teacher. This real-time interaction encourages active dialogue, questions, and clarifications, reinforcing student's understanding of anatomical structures. The immediate feedback provided during the learning process ensures accurate guidance and enhances the overall learning experience **(18)**.

VR offers a cost-efficient alternative to Conventional anatomy education, requiring fewer physical resources and allowing easy updates for the latest medical information **(19)**. However, implementation challenges include the initial setup cost of high-quality VR headsets and computers, which may be significant for educational institutions. As technology advances and becomes more widespread, costs are expected to decrease **(20)**. Ensuring accurate representation of human anatomy in VR content is another challenge, requiring meticulous validation against real anatomical structures and regular updates for quality assurance **(4)**. Addressing these challenges will enhance the overall effectiveness of VR-based anatomy education.

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Ethical Considerations

Not applicable.

Conflict of Interest

The authors declared no conflict of interest.

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