Original Research

ADVANCING ANATOMICAL EDUCATION: THE ROLE OF 3D VIDEO-BASED LEARNING

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ABSTRACT

Introduction: Anatomical education is a core component of medical training, yet traditional methods like lectures and cadaver dissections often fail to provide the depth of spatial understanding required for clinical practice. With the advent of educational technology, 3D video-based learning has emerged as a promising tool that may improve anatomical education. This study compares the effectiveness of 3D video-based learning apart from traditional teaching methods in enhancing students' understanding of human anatomy.

Methodology: A total of 100 MBBS first-year students participated in the study. These students were divided into two groups based on the parity of their roll numbers: Group A (Traditional Teaching) includes even roll numbers and Group B (3D Video-Based Learning) includes odd roll numbers. Group A followed the conventional anatomy curriculum, which included lectures, textbook study, and cadaver dissection. Group B was introduced to 3D video-based learning tools apart from their regular curriculum, which provided interactive, immersive visualizations of anatomical structures, enabling students to explore and manipulate 3D structure of the skull. Both groups completed a MCQ exam after the learning module. The quiz was designed to test; Basic anatomical knowledge (e.g., identification of structures), Comprehension of anatomical relationships and Spatial understanding of how structures interact within the skull. The exam consisted of 30 multiple-choice questions, each targeting specific learning outcomes. Group A took the exam based on the traditional learning methods, while Group B took the same exam after engaging with 3D video-based content. Both groups were given the same amount of time to complete the exam. The performance of both groups was analysed to evaluate differences in examination scores.

Result: Group a (Traditional Teaching): The average score for Group A was 68%. Students excelled in factual recall questions but performed poorly on questions that required spatial visualization of anatomical structures. Group B (3D Video-Based Learning): Group B scored significantly higher, with an average score of 82%. They performed better on questions requiring spatial understanding and the relationship between anatomical structures. Statistical analysis a significant difference indicating that 3D video-based learning was more effective.

Conclusion: This study demonstrates that 3D video-based learning significantly improves students' understanding of human anatomy, particularly in spatial visualization. The findings suggest that 3D technologies can complement traditional teaching methods, enhancing the learning experience for medical students. Further research is needed to assess the long-term effects and scalability of these tools in medical education.

Keywords: Anatomical Education, 3D Video-Based Learning, Spatial Visualization, Medical Education, Human Anatomy.

INTRODUCTION

Anatomy has long been regarded as a foundational Pillar of medical and health-science education, providing the structural knowledge required for clinical reasoning, diagnosis, and safe practice. Traditionally, anatomy teaching has relied heavily on cadaveric dissection, prosected specimens, textbook illustrations, and two-dimensional (2D) lecture-based instruction. While these methods remain pedagogically valuable, they are increasingly challenged by limitations such as reduced availability of cadavers, curricular time constraints, high maintenance costs, and the

www.ajmrhs.com
eISSN: 2583-7761

Date of Received: 22-02-2026
Date Acceptance: 01-03-2026
Date of Publication: 10-03-2026

difficulty students face when attempting to mentally reconstruct three-dimensional structures from static images With the introduction of reformed curricula in medical, dental and other allied health schools, most schools have reduced the total hours allocated for anatomy teaching and laboratory practical hours. These changes have been a continuous debate and triggered the emergence of innovative teaching and learning strategies to maximize student's learning of anatomy in the new context Anatomy is a discipline where spatial visualization is of importance. Students need to learn not just anatomical structures and functions but also spatial relationships to surrounding structures. While anatomy textbooks and anatomy atlases provide two-dimensional (2D) static anatomical illustrations, they are of limited value in exposing three-dimensional (3D) dynamics of anatomical structures.3 Learners may find it difficult to visualize 2D images as 3D and understand certain dynamic aspects of functional anatomy. For example, identifying the structures related to the caudate lobe when the liver is moved to different planes/positions. In anatomy, students must rotate and manipulate structures from various views to identify anatomical structures. Visual-spatial ability has been defined as the ability to mentally manipulate objectives in three dimensions.4 Such ability is important for medical students to understand anatomical structures and is also important to surgical trainees and surgeons. Therefore, the ability to visualize and mentally manipulate 3D structures and correctly identify them and related structures is an important skill to medical and dental students when the anatomy is presented in various planes and positions. Research in this area may not only assess visual spatial abilities of students during learning but also assess the development of a pedagogical technology to enhance students' learning skills and the advancement of medical training.

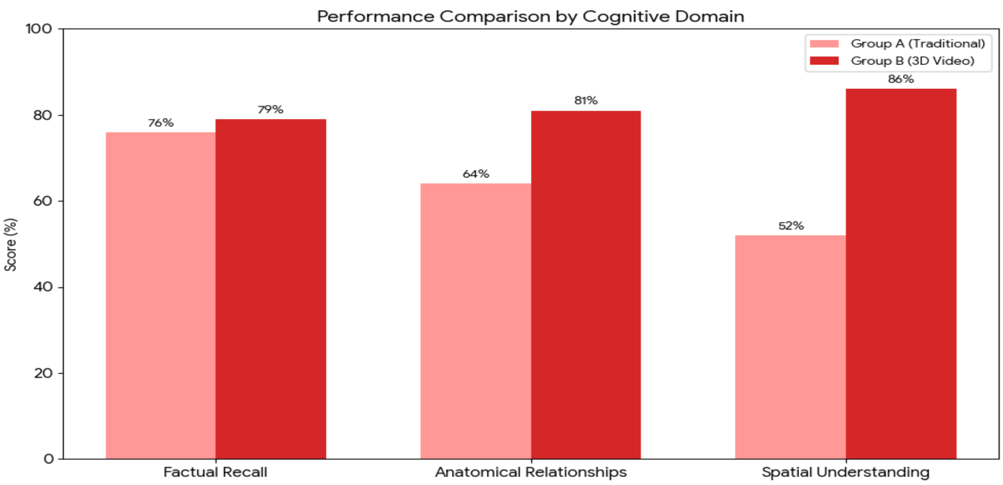
MATERIALS AND METHODS

Material: This study utilized 3D video-based learning materials, traditional 2D instructional methods, and standardized assessment tools. The 3D learning materials included interactive anatomy videos with rotatable and zoomable views, layer-by-layer dissections, stereoscopic animations, high-resolution 3D anatomical reconstructions, and web-based 3D simulation platforms. Traditional 2D learning methods consisted of printed textbook diagrams, static lecture slides, 2D instructional videos, photographs of cadaveric dissections, and flat anatomical diagrams of major body systems. Knowledge assessment was conducted using a validated multiple-choice question bank (20–30 items per session) focusing on structural identification, spatial relationships, and applied anatomy. Spatial ability was evaluated using the Mental Rotation Test administered before and after the intervention. Learner satisfaction and usability were assessed using a Likert-scale questionnaire measuring clarity, engagement, ease of understanding, perceived usefulness, and overall satisfaction. Cognitive load was measured using the Paas Cognitive Load Rating Scale. The study was conducted in a multimedia-enabled classroom equipped with computers, projectors, headphones, and high-speed internet access. Instruction was delivered by qualified anatomy faculty, with technical support provided by a multimedia assistant.

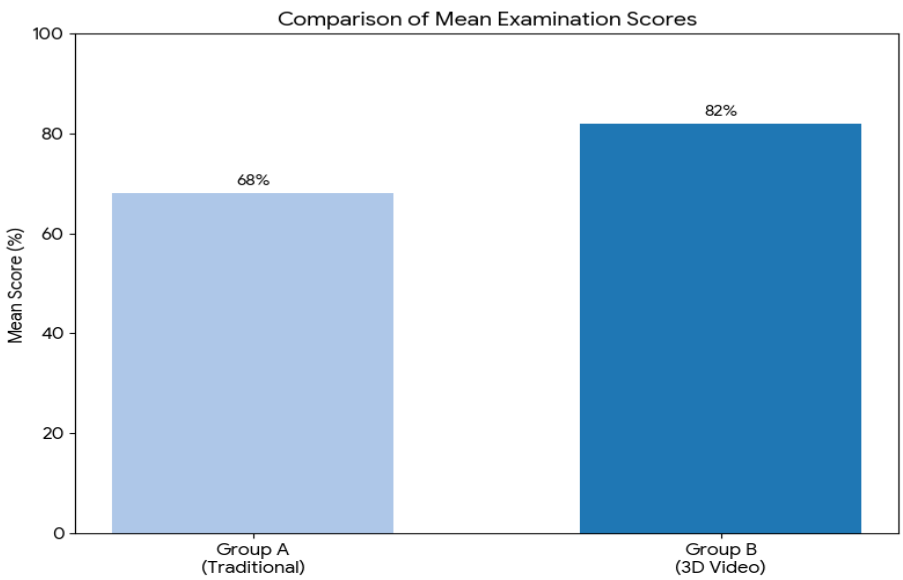
Methods: A quasi-experimental pre-test–post-test design was used to compare the effectiveness of 3D video-based anatomy learning with traditional 2D instructional methods. The study was conducted over four weeks as part of the regular postgraduate anatomy curriculum. Postgraduate medical students enrolled in the anatomy program were invited to participate. Inclusion criteria were enrolment in the course, informed consent, and no prior exposure to 3D anatomy learning tools. Participants were assigned to either Group A (3D video-based learning) or Group B (traditional 2D learning). Group A received instruction using interactive 3D anatomy videos featuring rotatable and zoomable models, layer-by-layer virtual dissections, animated views of complex structures, and high-resolution 3D reconstructions from CT/MRI datasets delivered via digital platforms such as Visible Body or BioDigital Human. Group B received conventional instruction using lecture slides, textbook diagrams, and 2D anatomy videos. Knowledge acquisition was assessed using a validated 20–30 item multiple-choice questionnaire administered as pre-test, post-test, and retention test. Spatial ability was evaluated using the Mental Rotation Test. Student satisfaction and perceived cognitive load were measured using standardized questionnaires. A retention test was conducted 2–4 weeks after the intervention to assess long-term learning outcomes.

RESULTS

A total of 100 first-year MBBS students completed the study and the post-intervention MCQ examination. All participants were included in the final analysis. The examination consisted of 30 multiple-choice questions assessing factual anatomical knowledge, comprehension of anatomical relationships, and spatial understanding of skull anatomy.



Students in Group A (Traditional Teaching) achieved a mean score of 68%. Their performance was relatively strong in questions related to basic identification and recall of anatomical structures. However, a noticeable decline in scores was observed for questions that required three-dimensional spatial visualization and understanding of complex anatomical relationships within the skull. In contrast, Group B (3D Video-Based Learning) demonstrated a higher overall performance, with a mean score of 82%. Students in this group showed consistent improvement across all domains, particularly in questions assessing spatial orientation and the interrelationship of anatomical structures. The immersive and interactive nature of the 3D video content appeared to facilitate a clearer conceptualization of anatomical depth, orientation, and structural continuity.



Comparative statistical analysis revealed a significant difference between the mean scores of the two groups, indicating that students exposed to 3D video-based learning performed significantly better than those taught using traditional methods alone.

DISCUSSION

The findings of this study highlight the positive impact of 3D video-based learning on anatomical education, particularly in enhancing students' spatial understanding of complex anatomical structures. While traditional teaching methods such as lectures, textbooks, and cadaveric dissections remain foundational to anatomy education, they may not adequately address the challenges students face in visualizing three-dimensional relationships. Students in the traditional teaching group demonstrated satisfactory performance in factual recall, which aligns with the strengths of lecture-based instruction and textbook learning. However, their lower performance in spatially oriented questions suggests limitations in translating two-dimensional representations and static cadaveric views into accurate three-dimensional mental models. In contrast, the significantly higher scores achieved by the 3D video-based learning group underscore the value of visual and interactive educational tools. The ability to rotate, zoom, and manipulate anatomical structures likely enhanced cognitive integration of form, position, and function. This immersive learning experience may reduce cognitive load and improve retention by allowing learners to actively engage with anatomical content rather than passively memorizing structures. These results are consistent with existing literature suggesting that 3D visualization tools improve spatial cognition, learner engagement, and conceptual understanding in medical education. The use of 3D video-based learning as a supplementary tool appears particularly beneficial for anatomically complex regions such as the skull, where overlapping structures and intricate spatial relationships are difficult to comprehend through traditional methods alone. Despite the encouraging results, this study has certain limitations. The assessment focused on short-term learning outcomes, and long-term retention was not evaluated. Additionally, the study involved a single cohort from one institution, which may limit generalizability. Future studies should explore long-term knowledge retention, application in clinical settings, and integration of 3D learning tools across multiple anatomical systems.

CONCLUSION

The present study demonstrates that 3D video-based learning is an effective educational tool for enhancing anatomical understanding among first-year MBBS students. Students exposed to 3D video-based resources showed significantly better performance in MCQ assessments compared to those taught exclusively through traditional methods. The most notable improvement was observed in questions requiring spatial visualization and comprehension of complex anatomical relationships, particularly within the skull. While traditional teaching methods remain essential for foundational knowledge acquisition, the findings suggest that they may be insufficient on their own for developing a strong three-dimensional understanding of anatomy. The integration of 3D video-based learning as a supplementary tool provides learners with dynamic, interactive visualizations that enhance engagement and conceptual clarity. Overall, incorporating 3D video-based learning alongside conventional teaching methods can significantly enrich anatomy education and better prepare students for clinical application. Further research involving larger sample sizes, multiple institutions, and long-term outcome assessment is recommended to evaluate the sustained impact and scalability of 3D learning technologies in medical education.

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How to cite this article: Dr. Muzamil Mushtaq, Dr. Javed. Ahmad Khan, Prof. (Dr). Ghulam Mohammad, Dr. Mudasir Ahmad Khan, Dr. Sajad, ADVANCING ANATOMICAL EDUCATION: THE ROLE OF 3D VIDEO-BASED LEARNING, Asian J. Med. Res. Health Sci., 2026; 4 (1):568-572.
Source of Support: Nil, Conflicts of Interest: None declared.