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Expert Opinion Article

Integrating Multimedia In Anatomy: A Study On The Role Of Video Demonstration In Osteology Learning

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1. Abstract

Background: Traditional teaching techniques of osteology involving use of static models and lectures are prone to the risk of failing to impart the three-dimensional interrelationship amongst bone structures. This becomes especially challenging to the first year medical and dental learners who require to have clear knowledge of skeletal anatomy to be used in clinical practice.

Aim: The study was set out to evaluate the effectiveness of instructor-narrated video demonstration as an addition to the typical osteology teaching (instructor only) to enhance student comprehension, recall and interest.

Methodology: A prospective interventional study was carried out in a study population of 200 first-year MBBS and BDS students who were randomly assigned to form control (n = 100) and experimental (n = 100) groups. The conventional lectures and models of bones were used to instruct the control group; on the other hand, the experimental group was taught through the use of high-resolution video demonstrations. The results of learning outcomes were captured using pre- and post-tests, an OSPE and student-completed feedback questionnaire.

Findings: The experimental group showed exceptionally greater gain in post-test with a mean gain of 30.94 as opposed to the gain of the control group which was 14.2 ($p < 0.001$). There was also improvement in student remarks with regard to increase in clarity, interest and comfort to revise using video based learning.

Conclusion: The effect on the results of learning osteology using video demonstrations is vivid. It is proposed that multimedia tools be implanted in courses of anatomy with the idea being to facilitate more knowledge and interaction among learners.

2. Keywords: Osteology, Anatomy Education, Multimedia Learning, Video Demonstration, Medical Pedagogy, Cognitive Load Theory

3. Introduction

The anatomical curriculum and the basis of medical and dental education is made up of osteology the scientific study of the human skeleton know as the backbone of anatomical learning. Excellence in bone morphology, landmarks, and articulatory relationships assists clinical thinking in a wide range of fields, including orthopaedics, radiology, and forensic medicine. Exhaustive skeletal knowledge directs diagnostic interpretation and surgical accuracy (Regulski *et al*., 2022). The traditional pedagogies relying on textbook diagrams and bone models often fail to capture the full three-dimensional complexity of skeletal anatomy. As anatomical curricula become progressively intricate, academic institutions are recognising the need to evolve teaching methods to foster deep spatial comprehension (Wolf, 2019). Enhancing osteology instruction remains a strategic priority for developing clinically proficient graduates primed for the demands of modern healthcare.

Conventional anatomy teaching still depends on passive methods 2D drawings, cadaveric samples, and fixed bone models. While cadaveric materials are realistic and haptic-based learning, they come at a high price, are in short supply, and can still cloud some spatial relationships for beginners. Rote-memorisation lectures are of little use in fostering conceptual knowledge, resulting in low participation and memorisation. Particularly in osteology, where three-dimensional perception is paramount, students often have difficulty visualising intricate articulations from flat images. The survey has revealed that undergraduate students studying anatomy of the human body prefer multimodal and interactive learning materials over the traditional ones (Raubenheimer *et al*., 2019). Although traditional practices are in a way needed, they are normally insufficient to accommodate the diverse needs of the current students, and pedagogical imagination is necessary.

Being a response to the shortcomings of the traditional instruction, computer-aided software and multimedia learning strategies became an inalienable constituent of the anatomy teaching. The presence of virtual reality, 3D visualisation programmes, augmented reality and video tutorials with narrations allows the students to study the anatomical structures in a way that is more interactive and intuitive (Barmaki *et al.*, 2023). In field as specific as osteology, digital cadavers and 3D models afford moving views of bony landmarks, orientation, and articulations that would otherwise be hard to glimpse with stationary resources (Border, 2019). The freedom with which students can create, pause, and restart demos at any given time can be more advantageous by allowing students to have self-directed revision and personal understanding (Birbara and Pather, 2021). The extensive study has already validated this opinion and confirmed that the use of visual-audio learning systems has a significant positive impact on the level of satisfaction and mental activity of the student as compared to the usual silent presentation (Abdulrahaman *et al.*, 2020).

Education models, such as the Mayer Cognitive Theory of Multimedia Learning, and Dual Coding Theory support teaching anatomy by means of multimedia. The model by Mayer states that it is more effective when a person learns utilizing visual + verbal method to reduce cognitive overloading by displaying visual information consistently with the narrative (Mayer, 2020). According to the Dual Coding Theory, a combination of imagery and storytelling will promote two mental representations, which makes the representation of memory and recall easier. Having applied experimental studies in the field of anatomy education, the researchers observed that multimedia-enhanced modules lowered the extraneous load and increased the germane processing (Mayer, 2024). Taken together, those theories offer a convenient model to utilize video-based involvement in teaching osteology with the help of guided narrative and high-fidelity visual media.

The growth of multimedia neuroanatomy and regional anatomy education, video-based osteology education, is underrepresented in the literature. Current e-learning resources tend to emphasise broad anatomy over bone-based material, and limited investigations are comparing video-assisted osteology instruction with traditional osteology instruction in rigorous experimentally controlled settings (Xiao and Adnan, 2022). Joint kinematic and osteological module application is still of limited magnitude and not subject to rigorous outcome evaluation (Hulme and Strkalj, 2017). Closing the gap, our research here examines if instructor-narrated video demonstrations significantly enhance understanding and hands-on performance in undergraduate osteology education, hence providing evidence for novel curricular approaches.

Study objective: The aim of the study is to assess whether video demonstration improves comprehension and performance in osteology learning.

4. Review of Literature

Anatomy education has long depended on cadaveric dissection, static images, and didactic lectures as core teaching methods. Such techniques have been widely held to be effective for establishing baseline knowledge, promoting professionalism, and teaching respect for the human form (Hamad and Jia, 2022). Nonetheless, changing curriculum requirements, fewer laboratory hours, and logistical issues in cadaver acquisition have underscored the drawbacks of these traditional methods. While cadaveric learning encourages haptic interaction and moral growth, it tends to be inadequate to satisfy the spatial and visual understanding requirements of contemporary students (Lampropoulos and Kinshuk,2024). Furthermore, differences in students' learning styles and larger class sizes mandate a more personal and scalable method. In turn, medical schools are investigating hybrid pedagogies that merge traditional dissections with ancillary digital technologies to deepen knowledge without sacrificing the experiential benefit of human dissection (Fitrianto and Saif, 2024).

Digital technologies have revolutionised anatomical sciences dramatically, bringing in dynamic modalities like 3D simulations, virtual dissection tables, and teaching videos. These innovations enable flexible, student-centred models that allow students to explore anatomical structures on their own and in repetitive cycles (Ditton, 2024). Multimedia-based education closes the gap between theoretical knowledge and clinical practice, enabling students to see structures in functional environments. For example, the merit of incorporating radiological imaging into learning musculoskeletal anatomy so that students can equate textbook anatomy with actual clinical images. This method not only enhanced knowledge recall but also enhanced students' skills in interpreting medical imaging. The application of radiology, when combined with digital materials, enhanced the learning process as a whole and promoted critical thinking, proving that multimedia is not just an addition but an improvement over traditional teaching.

Multimedia learning is underpinned by strong cognitive models, specifically Mayer's Multimedia Learning Theory and Dual Coding Theory. Both theories highlight that learning will be enhanced when visual and verbal information are integrated, as dual channels allow more profound cognitive processing. They concluded that students who received a structured pre-course integrating narrated images and interactive exercises showed enhanced learning results in veterinary anatomy. This discovery supports the notion that carefully constructed multimedia not only grabs people's attention but also structures information in a way that supports long-term retention. Moreover, directed narration in video content addresses the cognitive overload since it keeps incentivizing the learners on relevant frameworks and concepts by shutting out diversions. These thinking rules are highly critical to study in anatomy where the complexity of information and quantity of information tends to overwhelm new students rapidly. Learners can better understand using multimedia learning tools due to content division and alignment of sight with sound.

The anatomy of bones Osteology poses special pedagogical issues since it comprises a three-dimensional subject matter. It cannot memorise the morphology of bones, the surfaces of articulations, and the position of the space; it needs correct mental visualisation and the traditional resources might not be sufficient (Hu-Au and Lee, 2017). There is mention of the value of 3D modelling in their craniofacial development book in making students understand growth patterns and morphological variations. Similarly, Ditton (2024) provided a specific conceptual contribution by emphasising the usefulness of statistical shape modelling to display slight anatomical variation and pathology, thereby giving to the concept. With these tools adapted to their use in osteology, there is a possibility of transforming the manner in which students understand and approach skeletal shapes. Rather than bones as objects that a student can only interact with, the student can interact with them in a dynamic way rotating, dissecting and analysing in real life. This interactive approach fits the learning modes of the majority of medical students of the spatial and kinesthetic typology and brings better results not only in the practical examination but also in the clinical reasoning tasks.

5. Materials and Methods

5.1 Study Design

The study used a prospective interventional design to examine the effect of video demonstrations on osteology learning. It was done during the university academic term at one institution after ethical clearance. The study sought to assess the effectiveness of multimedia-enhanced instruction compared to standard teaching methods. Two parallel groups were created in order to enable controlled intervention. The design facilitated systematic comparison of student performance and feedback prior to and after the instructional sessions. The research also incorporated both qualitative and quantitative methods of data collection to facilitate a proper understanding of educational outcomes gained through video demonstration.

5.2 Participants

There were a total of 200 first-year undergraduate students studying in MBBS and BDS courses. All the participants were randomly distributed into a control group (n = 100) or an experimental group (n = 100) via a computer-generated randomisation process. Inclusion criteria included regular attendance at anatomy classes and no advanced previous exposure to osteology. Informed consent was obtained from all students, and their involvement was voluntary. The demographic spread between the two groups was even. Participants were guaranteed confidentiality and told that the results would only be used for teaching improvement and academic research purposes.

5.3 Group Allocation and Intervention

Students in the control group were taught via traditional means, such as chalk-and-talk lectures, printed notes, and direct observation of physical bone models. In contrast, the experimental group was instructed with high-definition instructor-narrated videos illustrating osteological principles with visual and spatial clarity. The lectures for the two groups were delivered by the same instructor to maintain parity in teaching. Every module of teaching was of the same length and conveyed the same content. The video demonstrations were projected in a classroom environment with the support of a projector and loudspeaker for sounds to make them visible and audible to all the students.

5.4 Teaching Topics

The chosen instructional material was on clinically important and structurally varied bones such as the femur, humerus, vertebrae, and skull. The subjects were picked on account of their elaborate morphology and importance in the medical curriculum. Identification of bones, anatomical landmarks, articulating surfaces, and orientation was highlighted in each session. Control and experimental groups received identical lesson plans to ensure uniformity in terms of scope and sequencing. Instructional aids like labelled diagrams and models were utilised in the control group, whereas animated overlays and 3D rotation tools were added to the video material in the experiment group. Discussion and question time were the same in both versions.

5.5 Assessment Tools

Learning achievements were measured with cognitive as well as practical assessment tools. A pre-test comprising 20 MCQs and 10 image-based identification questions was given before instruction.

After the sessions, the same post-test was administered to gauge improvement. Practical competency was tested through an Objective Structured Practical Examination (OSPE) in which students labelled anatomical landmarks at various stations. Student feedback was also obtained with a structured 5-point Likert-scale questionnaire regarding clarity, interest, and retention of content. These tools facilitated data triangulation, giving evidence of knowledge acquisition, technical skills, and learner feedback regarding the teaching approach.

5.6 Data Analysis

The data collected were analysed with Excel. Scores on pre-test and post-test within and between the two groups of 100 participants each were compared using paired and unpaired t-tests. Analysis of variance (ANOVA) was used to find out whether or not there was any statistically significant difference in performance across subgroups of demographics. Effect sizes were computed to measure the extent of improvement. Qualitative feedback data from the forms were analysed using thematic analysis, grouping common trends like clarity, motivation, and usability. All statistical analyses were carried out at a 95% confidence level, and p-values < 0.05 were taken as significant. Analysis assisted in establishing the instructional effectiveness of the video demonstration.

6. Results

6.1 Pre-test and Post-test Scores Comparison

Both groups had the same pre-test scores, with a slight difference in the score of the control group, at 48.10 ± 6.40 and that of the experimental group being 46.94 ± 5.81. The instructional intervention, the post-test score of the control group went up to 62.30 ± 6.40 compared to that of the experimental group, which posted a higher score of 77.88 ± 7.83, as shown in Table 1. The mean gain in the control group was 14.20, and for the experimental group was 30.94. Statistical tests showed the p-values as < 0.01 and < 0.001, respectively, which meant that significantly higher learning results were achieved through video-based instruction.

Table 1. Comparison of Pre-test and Post-test Scores Between Control and Experimental Groups (n = 200)

Group	Pre-test Score (Mean ± SD)	Post-test Score (Mean ± SD)	Mean Score Gain	p-value
Control (n = 100)	48.10 ± 6.40	62.30 ± 6.40	14.20	< 0.01
Experimental (n = 100)	46.94 ± 5.81	77.88 ± 7.83	30.94	< 0.001

Note: p-values derived using paired t-tests within groups. Between-group comparisons were analysed with unpaired t-tests. Effect size (Cohen's d) for experimental group = 1.83, indicating a large effect.

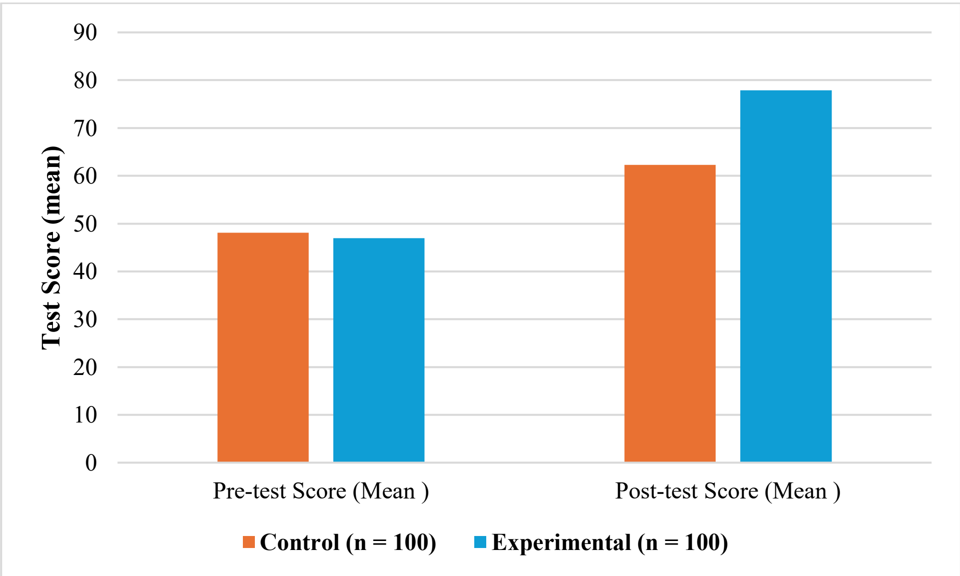

Figure 1: Comparison of Pre-test and Post-test Scores Between Control and Experimental Groups

The control and experimental group performance before and after treatment. Both groups started with scores very close to each other on the pre-test. Nonetheless, after the instructional sessions, the experimental group that had video-based instruction had a much higher post-test score than the control group, as shown in Figure 1. Average test scores are given on the y-axis, and the x-axis segregates pre- and post-test scores. The colour-coded bars denote the contrast in learning outcomes where the experimental group exhibited significant improvement, asserting the efficacy of video-augmented osteology learning.

6.2 Student Feedback Summarisation on Video-Based Learning

The student feedback on video-based osteology teaching. The majority of the students strongly agreed that the videos enhanced clarity (60), engagement (56), and ease of revision (67). There were more positive responses in the "Agree" column for all items, with a few who disagreed, as shown in Table 2. There were a few neutrally or negatively responding students, reflecting overall contentment with the teaching method. The format enabled learning at self-paced learning, which improved retention and understanding. These reactions reaffirmed that video demonstrations were favorably received and effective in presenting osteological concepts in a lucid, engaging, and accessible format.

Table 2. Summary of Student Feedback on Video-Based Learning (Experimental Group, n = 100)

Feedback Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Clarity of Content	60	30	6	3	1
Engagement in Learning	56	31	9	3	1
Ease of Revision	67	25	6	2	0

Note: Data collected via a 5-point Likert-scale questionnaire. Responses reflect students' perceptions of video-based osteology instruction.

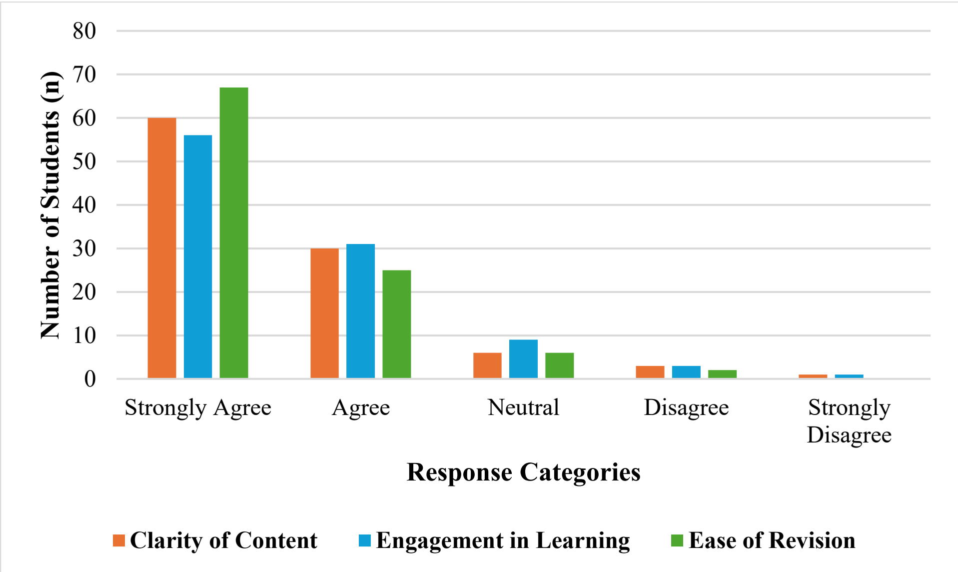

Figure 2: Student Feedback on Video-Based Osteology Learning

These students' responses to three areas of video-based osteology teaching: content clarity, learning engagement, and revision ease. The x-axis displays five response levels, and the y-axis indicates the number of students responding at each level, as shown in Figure 2. All but two participants strongly agreed that the videos enhanced clarity, engagement, and revision, and ease of revision had the largest number of "Strongly Agree" responses. Agreement and neutral responses came next, with little disagreement noted. These findings emphasise strong student acceptance of video-based approaches in anatomy education, specifically for their clarity and utility in self-study.

7. Discussion

The study demonstrated a substantial advantage for the experimental group: students who received video-based instruction achieved significantly greater improvements in post-test scores than those taught via conventional methods. The experimental cohort's mean gain of 30.94 points, compared with 14.2 in the control group ($p < 0.001$ vs. $p < 0.01$), strongly indicated that multimedia-enhanced teaching improved learning outcomes more effectively. The extent of the difference indicated that integrating visual and auditory information can hasten understanding, particularly in multifaceted fields such as osteology, where spatial geometry is paramount.

These results complement the Cognitive Theory of Multimedia Learning (CTML), which states that students process information through distinct auditory and visual channels and that dual-channel presentation lowers extraneous cognitive load and fosters meaningful learning (Mayer, 2024)

CTML stresses choosing, structuring, and combining visual and verbal materials in short-term memory prior to storing in long-term memory, principles that are well adapted to video instruction with narration. Video design also uses segmentation to divide complicated material into suitable chunks, and so minimise load and maximise retention (Zheng *et al*., 2022)

Repeatability was a primary advantage: students were able to pause, rewind, and review difficult sections, facilitating self-controlled review and enhancing long-term retention. Improved spatial orientation was facilitated by 3D rotations and animated overlays, both of which helped to better visualise articulating surfaces and landmark relations, activities that static models can rarely help students perform effectively. Independent learning was also encouraged: students enjoyed the flexibility of video-based learning, which allowed for out-of-class review and individualised pacing. Comparable outcomes have been noted in wider anatomy teaching studies, such as enhanced engagement and test scores with multimedia resources (Barmaki *et al*., 2023)

A number of limitations need to be stated. As a pilot study at a single institution, the findings could not be generalised to other environments or curricula. An extension of the study to multiple institutions with diverse student populations would increase external validity. All four bones were covered (femur, humerus, vertebrae, skull), and although the sampling was not random, this restricts the generalizability to the entire osteology curriculum. The research only measured short-term gains; no retention or clinical application was tested in the long term. Subsequent longitudinal studies will need to assess long-term knowledge and competence. The intervention also needed technical infrastructure, projectors, consistent video playback, and internet access, which may not be universally accessible in low-resource or rural training environments.

The significant learning gains, incorporating video-based material into the anatomy curriculum, are highly recommended. A hybrid learning model having students watch pre-recorded video modules before live sessions would eliminate redundant in-person time for active learning, model-based practice, or OSPE stations. A flipped classroom approach, where students view narrated video content at home and interact with guided-peer activities in class, would maximally enhance knowledge building and deepen understanding. Faculty development programs should be initiated to train educators in multimedia content creation, video scripting, and best practices in instructional technology.

8. Conclusion

This study underscores the high pedagogical worth of video illustrations as an adjunct to conventional osteology education. The utilisation of teacher-narrated videos helped students understand intricate anatomical complexes better, promoting enhanced theoretical comprehension and practical handling. In contrast to standard lecture-driven approaches, video-supported teaching provided enhanced spatial visualisation, recoverable content retrieval, and increased learner participation. These advantages were especially noticeable in the experimental group's performance and remarks, validating that multimedia-based learning can overcome the drawbacks of static models and passive learning environments. Based on these results, the incorporation of multimedia tools, especially video-based modules, into anatomy curricula must be highly promoted. Their adaptability facilitates self-paced learning and accommodates various student preferences, making education more inclusive and efficient. Nonetheless, this research was constrained by limited duration and a single-institution design. In order to optimally test the long-term effects of video-based learning, subsequent studies will need to incorporate larger populations and longitudinal designs. These studies would shed more light on knowledge retention, clinical utility, and cost-effectiveness of multimedia-supported anatomy education. Ultimately, integrating traditional pedagogy with technical innovation provides a promising route toward future modernisation of anatomical sciences for the next generation of students.

9. Recommendations

On the basis of this study, some practical implications can be put forward to improve the education of osteology. Institutions should give top priority to creating tailored multimedia materials tailored to their own curriculum and learning goals. Training should be provided specifically to faculty members for creating multimedia content so that educational videos are pedagogically sound and technically proficient. Integrating hybrid pedagogical formats that incorporate video demonstrations followed by classroom or lab work can give the student a more integrated and interactive learning experience. Further, engaging students in the development of teaching video content can encourage greater understanding, shared learning, and improved ownership of the learning experience.

10. Limitations

Although this study was rewarding in its findings, there are some limitations to be noted. The study was done as a pilot study within a single institution and, as such, might limit generalisation of the results to other student populations or academic institutions. Instructional content was restricted to only a few exemplar bones, with more comprehensive osteological subjects being ignored. The test also merely measured short-term learning gains, without measuring long-term retention or clinical use. Finally, variability in students' access to digital devices and stable internet may have affected their capacity to completely participate in the video-based learning, presenting the case for infrastructure support for future interventions.

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