Effectiveness Of E-Learning In Addition To Conventional Learning In Acquiring cross sectional anatomical knowledge among Phase I MBBS Students

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Abstract
Introduction: Learning Cross-Sectional Anatomy (CSA) solely through conventional methods is insufficient for Phase I MBBS students to accurately identify basic anatomical structures in CT and MRI images. This knowledge is crucial for identifying pathologies at undergraduate, postgraduate, and clinical practice levels. The aim of this study is to bridge this gap by teaching students basic anatomy and its variations using real cross-sectional images of CT and MRI through an e-learning module.
Methodology: A total of 100 Phase I MBBS students participated in this study, which involved a teaching module on CSA using CT and MRI images for six regions: Upper limb, Lower limb, Thorax, Abdomen, Head & Neck, and Brain. The e-learning content was presented as PowerPoint presentations with voiceovers and was hosted on a custom Moodle-based website for student access. The study spanned 10 months and supplemented the traditional learning of CSA through cadaveric dissection and chart-based methods. Pre- and post-test assessments were conducted to evaluate the effectiveness of the intervention.
Results: Post-test scores for all six regions showed statistically significant improvement in acquiring CSA knowledge through the e-learning module. The consolidated average scores across all interventions were: pre-test 5.52 ± 0.82 and post-test 18.97 ± 0.49, highlighting the effectiveness of the e-learning approach in complementing traditional teaching methods.
Conclusion: The addition of an e-learning module to conventional CSA teaching significantly enhances Phase I MBBS students' competency in interpreting basic anatomical structures in CT and MRI images. This integrated approach prepares students for better understanding and application of radiological anatomy in clinical practice.
Research Question: Does e-learning, in addition to conventional methods, improve cross-sectional anatomical knowledge acquisition among undergraduate medical students?

Key words: Cross sectional anatomy, MOODLE, CT, MRI

INTRODUCTION:

Anatomy is a fundamental and voluminous subject in medical education, forming the foundation for understanding the structure and function of the human body. It encompasses various branches such as Embryology, Histology, Radiology, and Gross Anatomy, each contributing uniquely to the medical curriculum. In India, the Phase I MBBS curriculum requires students to master these domains within a limited one-year period, presenting significant challenges in achieving comprehensive understanding. Among these branches, Cross-Sectional Anatomy (CSA) has become increasingly relevant in the context of modern diagnostic imaging, particularly with advancements in technologies like Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). CSA involves studying axial (transverse), coronal, and sagittal sections of the human body, focusing on identifying anatomical structures in these planes.

Despite its importance, CSA remains a "gray area" in the curriculum, lacking explicit and structured teaching. Conventional methods of anatomy instruction, such as cadaveric dissections and labelled charts, primarily focus on gross anatomy and provide limited exposure to cross-sectional perspectives. [1] Moreover, the undergraduate curriculum in India restricts radiological anatomy to basic plain and contrast X-rays, leaving students ill-prepared to interpret complex CT and MRI images. This gap in CSA education impacts the confidence and competency of Indian medical graduates, not only at the undergraduate level but also during postgraduate training and clinical practice. [2,3]

The integration of CSA into radiological anatomy, using real cross-sectional images from CT and MRI, is crucial to address this deficiency. Traditional methods alone are insufficient for students to develop the necessary skills

to diagnose and interpret abnormalities in radiological images. [4] This challenge underscores the need for innovative teaching methods that complement conventional approaches.

Several studies have explored innovative methods to bridge this educational gap. Kazoka et al. demonstrated that digital technologies like the 3D virtual dissection table "Anatomage" significantly improved students' ability to identify anatomical structures through interactive cross-sectional imaging. [5] Medical students exposed to such digital tools developed a better understanding of anatomical relationships by visualizing structures in various sectional planes, underscoring the importance of integrating CSA learning into anatomy education. [6] Similarly, Jahira Banu et al. used a modified Peyton's teaching approach involving cadaveric cross-sectional demonstrations and peer-assisted learning, which resulted in improved spatial understanding and anatomical interpretation skills among medical students. [7] Their approach emphasized learning through structured demonstrations, peer feedback, and independent practice, facilitating long-term knowledge retention.

Additionally, Guilhermne et al. investigated the application of technology-enhanced collaborative learning in sectional anatomy using different e-learning platforms. [8] Their study highlighted the effectiveness of multimedia learning tools designed with the Cognitive Theory of Multimedia Learning (CTML) framework, which improved student engagement and knowledge retention. Despite using different technologies, all student groups showed significant learning gains, emphasizing the potential of technology-driven anatomy education.

E-learning provides unparalleled convenience and accessibility, enabling students to access resources regardless of time or location. This flexibility has gained significant attention, particularly in the wake of the COVID-19 pandemic. The global educational landscape underwent a rapid transformation during the pandemic, compelling academic institutions to shift from traditional teaching methods to online platforms. While some universities had already embraced digital learning for its accessibility and user-friendly nature, the pandemic accelerated this transition, particularly in clinical education. The shift to online learning leveraged electronic technologies to deliver consistent educational content, foster clinical reasoning, and develop core medical competencies. It introduced innovative teaching methods and facilitated documentation of student engagement and performance assessments. Despite these advantages, challenges such as reduced opportunities for hands-on practice, difficulty teaching physical examination techniques, and limitations in evaluating clinical competencies became evident. These hurdles sparked concerns about the adequacy of online and blended learning models in preparing students for clinical roles.

Nevertheless, the lessons learned from this period of forced innovation continue to shape the future of medical education. While most institutions have returned to in-person learning, certain adaptations from online teaching have the potential to enhance traditional pedagogical methods. The overarching goal remains to ensure that all students achieve the necessary clinical competencies, regardless of the format employed. This shift may lead to the development of more flexible and robust teaching strategies, ultimately equipping students with the skills required to meet the demands of a post-pandemic healthcare environment.

In the era of advanced medical technologies, incorporating radiology education into the anatomy curriculum has become essential for developing competent future healthcare professionals. The introduction of E-learning methods into Phase I MBBS teaching can bridge the gap in CSA education, fostering better integration of anatomical and radiological knowledge. Studies suggest that teaching radiological imaging alongside gross anatomy improves knowledge retention and comprehension among students, while electronic resources further support learning across diverse areas. [9] This study aims to evaluate the effectiveness of E-learning in enhancing CSA knowledge, using CT and MRI images, and its potential as a complementary tool to traditional anatomy teaching. [10]

By integrating real cross-sectional radiological images with traditional anatomy teaching, E-learning can bridge the existing gap in CSA education, fostering better retention and understanding of anatomical concepts. [11] This approach aligns with the evolving landscape of medical education, where innovative methodologies play a crucial role in preparing future healthcare professionals. By addressing these aspects, this study aims to contribute to the evolution of anatomy education, aligning it with advancements in radiological and clinical practice, and ultimately bridging the gap in CSA teaching within the undergraduate curriculum.

MATERIALS AND METHODS:

This study was conducted after obtaining approval from the Institutional Ethics Committee (IEC) in September 2021 (No: 2130101). Consent forms and an acceptance letter from the affiliated department were secured prior to commencing the study. The study included all 100 Phase I MBBS students to provide comprehensive knowledge of Cross-Sectional Anatomy (CSA) in radiological anatomy.

The study was designed as a quasi-experimental study and conducted over a period of 10 months in a designated medical institution. The target population consisted of 100 Phase I MBBS students, who were subjected to both traditional and E-learning modules for CSA education. The traditional learning methods included cadaveric dissection and labeled anatomical charts, while the E-learning module focused on radiological anatomy using CT and MRI imaging.

For the E-learning module, a dedicated website was developed on the Moodle online platform. The course content, including CT and MRI labelled images obtained with permission from the Department of Radiology,

was uploaded. PowerPoint presentations with voice-over explanations were used as the primary teaching tool. The module covered six anatomical regions—upper limb, lower limb, thorax, abdomen, head and neck, and brain. For each region, two levels of cross-sectional images and their anatomical parts were taught, emphasizing reconstruction planes.

The study procedure included a pre-test administered to students before the E-learning sessions. The pre-test involved displaying CT and MRI images with marked anatomical structures, requiring students to identify them. Each correct identification was awarded one mark, and 20 questions were provided for each anatomical region. Over six months, the E-learning module was delivered in conjunction with traditional learning. At the end of each E-learning session for a specific region, a post-test assessment was conducted using the same format as the pre-test.

Quantitative data from the pre- and post-tests were analyzed using the Student's T-test to determine the effectiveness of the E-learning module. Additionally, qualitative feedback was collected through a Google Forms questionnaire at the end of the study to assess student perceptions of the E-learning module. The feedback responses were interpreted to provide insights into the integration of E-learning with traditional teaching methods for CSA education.

RESULTS:

The study evaluated the impact of integrating radiological cross-sectional anatomy (CSA) learning with traditional methods (cadaveric and charts) for Phase I MBBS students. Before the intervention, students had acquired basic CSA knowledge through conventional methods. The introduction of the radiological CSA module significantly enhanced their understanding, as reflected in the post-test scores. The pre- and post-test scores for each anatomical region were analyzed using a paired T-test, which demonstrated a statistically significant two-tailed p-value of less than 0.0001. The average pre-test score across all regions was 5.52 ± 0.82, which improved to 18.97 ± 0.49 in the post-test, indicating a substantial enhancement in student performance. Region-wise, the average pre-test and post-test scores showed consistent improvements: for the upper limb, the scores were 6.34 ± 2.18 and 18.58 ± 2.61, respectively; for the lower limb, 5.26 ± 2.07 and 19.64 ± 2.32; for the abdomen, 4.54 ± 2.12 and 19.46 ± 2.34; for the thorax, 6.23 ± 2.72 and 18.58 ± 2.68; for the head and neck, 6.12 ± 2.12 and 18.54 ± 2.62; and for the brain, 4.64 ± 2.08 and 19.02 ± 2.32. [Table No.1]

Table No.1.: Comparison of Pre-Test and Post-Test Scores in CSA Radiological Anatomy Across Anatomical Regions

S. NO	Anatomical region	Number	Pre - test score in CSA radiological anatomy (average) (out of total mark 22)	SD	Post - test score in CSA radiological anatomy (average) (out of total mark 22)	SD
1	Upper limb	100	6.34	2.18	18.58	2.61
2	Lower limb	100	5.26	2.07	19.64	2.32
3	Abdomen	100	4.54	2.12	19.46	2.34
4	Thorax	100	6.23	2.72	18.58	2.68
5	Head &Neck	100	6.12	2.12	18.54	2.62
6	Brain	100	4.64	2.08	19.02	2.32
	Mean		5.52	0.82	18.97	0.49

Qualitative feedback was collected using a Google Form with a three-point Likert scale, and the responses highlighted overwhelmingly positive student perceptions of the module. All students (100%) reported a clear understanding of the project, and 99% found the Moodle-based learning module easy to navigate. Additionally, 100% confirmed gaining knowledge of radiological CSA, 97% acknowledged learning basic CSA in CT and MRI, and 96.2% found traditional methods helpful for understanding CSA. Furthermore, 100% of students indicated an ability to identify anatomical parts in CT and MRI images after the study, 96.2% found the study easy to understand, and 97% agreed that combining radiological CSA with traditional methods was effective for acquiring knowledge. These findings underscore the effectiveness of the E-learning module in enhancing students' understanding of CSA, complementing traditional teaching methods, and equipping them with essential radiological anatomy interpretation skills.

DISCUSSION:

The integration of radiological cross-sectional anatomy (CSA) teaching with traditional methods proved to be highly effective in enhancing the knowledge and skills of Phase I MBBS students. The study demonstrated a significant improvement in post-test scores across all anatomical regions, indicating the success of the

intervention. Students could identify all basic anatomical parts in radiological images after engaging with the Moodle-based teaching module. The highest post-test scores were observed in the lower limb region, suggesting the module's clarity and students' ability to grasp the anatomical details of this region effectively. Despite the inherent complexity of mediastinal and lung anatomy, students achieved high post-test scores in the thorax region, reflecting the module's ability to simplify and present challenging content effectively.

Similarly, CSA knowledge acquisition in the abdomen is typically difficult due to the multitude of anatomical structures; however, students excelled in the post-test, indicating their comprehension of the region's radiological anatomy. Head and neck anatomy and brain anatomy, traditionally challenging even for postgraduate students, were tackled effectively, with students achieving remarkable post-test scores, further underscoring the efficacy of the Moodle module in facilitating advanced anatomical understanding.

This study aligns with the findings of Jeffry DR et al., who highlighted the lack of basic radiological anatomical knowledge among final-year medical students, leading to poor interpretation of common conditions in chest radiographs. [12] Introducing radiology teaching modules early in the curriculum, as shown by Lanier L, provides clear anatomical recognition and enhances future understanding of pathology and clinical radiology. [13] Murphy et al. demonstrated that even a short, focused radiology teaching module for Phase I students significantly improved their post-test scores, supporting the findings of the present study. [14]

Positive findings from this study align with the evolving global perspective on online anatomical education, as highlighted by Brasset et al. [15] The COVID-19 pandemic has revolutionized the way medical education is delivered, emphasizing the importance of e-learning as a viable and essential teaching method. Brasset et al. point out that this shift presents opportunities for the anatomical community to embrace innovation, cooperate globally, and establish best practices for teaching in a post-pandemic world. The ability to rigorously evaluate online teaching's strengths and weaknesses during such unprecedented times has allowed educators to refine their methods and adapt to new challenges.

The post-test results highlight the importance of a practical approach in teaching CSA to medical students. A blended learning model that combines online methods with traditional approaches significantly enhances knowledge retention, as supported by the positive student feedback in this study. Over 95% of students could identify basic anatomical parts easily through e-learning, and 100% reported a clear understanding of the project. The use of Moodle for learning provided flexibility and convenience, allowing students to learn at their own pace, which contributed to the success of the intervention. The ability of digital learning tools to improve assessment outcomes and satisfaction, as shown by McGee et al., aligns with the present study's findings. [16]

The current study, which shows significant improvements in anatomy knowledge through an e-learning module, aligns with Barry et al.'s findings that many students use online platforms like YouTube for anatomy learning. [17] Both studies highlight the importance of integrating digital resources in anatomy education, with the current study focusing on structured e-learning while Barry et al. emphasize student-driven use of social media. Both approaches demonstrate effective ways to enhance learning for modern students.

However, the study had limitations. As this was the first introduction of radiological CSA learning for Phase I MBBS students, the post-test scores were not compared with those obtained solely through traditional methods. Additionally, challenges associated with online learning, such as technical issues and limited IT skills, as noted by Abbas U et al., were not reported in this study, likely reflecting differences in infrastructure and resources between the current and Abbas' study conducted in a lower-income setting. [18]

Despite these limitations, the present study demonstrated that students and faculty are largely in favor of adopting e-learning alongside traditional methods. As highlighted by Shashikant Dhir et al., the advantages of this blended approach outweigh the challenges. [19] Digital tools, when combined with effective teaching strategies, can provide cost-effective and scalable solutions to improve medical education, particularly in fields like radiology. The high scores achieved by students in challenging regions such as the head, neck, and brain further support the feasibility and effectiveness of incorporating e-learning in the early stages of medical education.

In conclusion, the study demonstrates the significant potential of e-learning platforms in improving knowledge acquisition and practical skills in radiological CSA, making it a valuable addition to traditional teaching methods.

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