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The choice of the methodology for scaffolding the concepts of Anatomy: the learner's perspective triangulated with academic performance

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ABSTRACT

Understanding the complexity of the human body is a requirement for being a skilled clinician, and the study of human Anatomy serves as the basis for medicine. This study identifies students' preferred teaching methods for understanding Anatomy and triangulates the effects of various methods with their academic performance. Methods: A cross-sectional study was conducted over two weeks at the HITEC-Institute of Medical Sciences Anatomy Department involving 100 first-year MBBS students. Students were randomly divided into three batches and exposed to three teaching methodologies: PowerPoint (PPT), Whiteboard & Anatomical Models, and Case-Based Learning (CBL). Academic performance was evaluated using MCQ-based tests, and student perceptions were recorded using a 5-point Likert scale questionnaire. Results: There was a statistically significant difference in academic performance, with students taught via whiteboard and anatomical models achieving higher mean scores (59.4 ± 26.6) compared to PPT (55.6 ± 26) and CBL (46.8 ± 33.4) ($p=0.007$). Furthermore, students perceived that anatomical models and board teaching provided better continuity of previous knowledge and were more interest-stimulating. Conclusions: Traditional whiteboard teaching supported by anatomical models remains an optimum approach for early medical education, yielding both the highest academic success and positive student perception compared to PPT and CBL.

Introduction

Understanding the complexity of a human body is a requirement for being a skilled clinician, and the study of human Anatomy serves as the basis for medicine (1,2). Medical students are taught Anatomy through a variety of techniques, such as dissection on cadavers, lectures, active demonstration in small groups, the use of models, computer-assisted learning (including slides and films), the use of living subjects and radiology, etc. (3). Gross Anatomy, histology, and embryology are fundamental basic disciplines of Anatomy that every medical student must understand (4). Gross/regional Anatomy not only provides the very basic platform to all the clinical branches of medicine, but also regarded as having complicated concepts (5,7). To reach as many different types of learners as possible, it is vital to use a variety of strategies (6). Different modern educational strategies/methodologies in teaching and learning Anatomy for undergraduate medical students are in practice, but for teaching regional Anatomy we preferably use the small group demonstrations in which content is presented in the form of PowerPoint presentations, or with the help of white board and anatomical models, or Case Based Learning (CBL) (7,8,9).In order to determine the best teaching strategy facilitating the learning process, it is vital to understand the perspectives of the students in regards to these three methodologies. Due to availability of relatively shorter time for studying large curriculum of Anatomy, there is a need to explore the actual perception of the students regarding their preferred method (Board and models, PowerPoint, CBL) for learning the concepts of Anatomy (10,11). Hence, this study is conceived to identify students' preferred method for understanding Anatomy, and triangulate the effects of various methods with their academic performance. This will provide a foundation for giving their best-chosen method more preference into routine teaching practice to make the difficult concepts of Anatomy favorable, palatable and informal for the undergraduate medical students.

Our study will also be a platform for future study on comparison of teaching aids, and also to identify pros and cons of various teaching methods from student's lens.

Methodology:

This cross-sectional study was conducted at HITEC-Institute of Medical Sciences Anatomy Department over a period of 2 weeks, after the approval of the institutional ethics committee. Purposive sampling technique was employed to engage 100 first year MBBS students after the informed consent, who were taught an academic module through the integrated curriculum at level 7. Any student who missed any of the session was excluded from the study.

The whole class of 100 students was divided randomly into three batches of 33,33 & 34 students each. Three topics of comparable difficulty level were chosen. Each batch was exposed to three teaching methodologies according to the following plan.

	Batch A	**Batch B**	**Batch C**
Round I (Topic-1)	PPT	Board& Models	CBL
	MCQ's Test		
Round II (Topic-2)	CBL	PPT	Board & Models
	MCQ's Test		
Round III (Topic-3)	Board & Models	CBL	PPT
	MCQ's Test		
Final	Feed Back Questionnaire about three teaching modalities		

Each batch appeared in a MCQ's based mini test after each session. At the end of the last session a validated questionnaire adopted from Jabeen and Ghani (3) was filled by the students, rating three teaching methods on five-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 =Neutral, 4 = Agree, and 5 = Strongly agree). The data analysis was done by using SPSS 22. The Likert scale was calculated in number (percentage). Three groups were made on the basis of academic performance, mean and standard deviation were calculated for each group followed by the ANOVA to compare the academic performances.

Results:

Total number of students who appeared in the tests and filled the questionnaire was 100. Both male and female students of first year MBBS participated. There was a statistically significant difference between the means of the total grades scores for

the three teaching methods, where students taught by white board and anatomical models achieved higher grades in comparison to those taught by PowerPoint presentations and CBL. Means and P values are shown in Figure-I & Table-I.

The students were asked various questions regarding the effectiveness of the three teaching methodologies, and their perceptions yielded a significant difference within and between the groups. The anatomical models and board teaching methodology **provided better continuity of previous knowledge,** was more interest stimulating and enhanced the ability to integrate text with figures in comparison to other two. (Table II & III).

However, majority of the students opined that the white board and CBL learning tools provided them with better clarity of new terms, spellings and diagrams.

(Table III)

Figure I: Distribution of the means of the students' final grades achieved after teaching by three methods

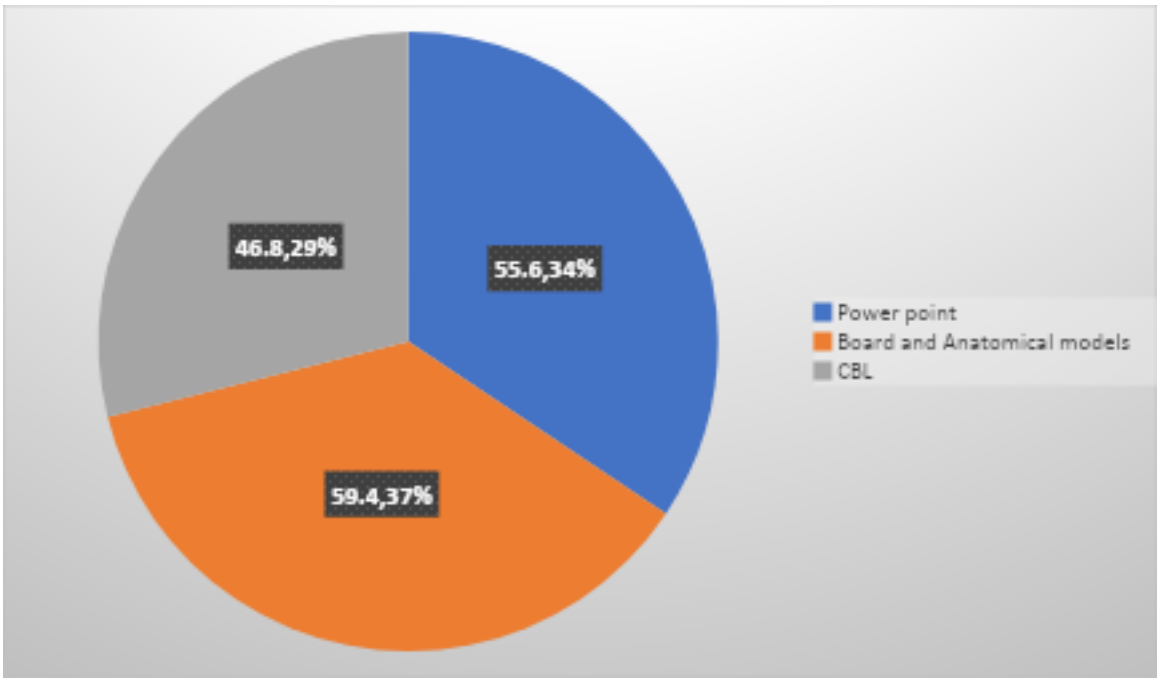


Table-I: Distribution of the means of the students' final grades &

P-value achieved after teaching by three methods as calculated by

one -way ANOVA

Teaching Methodology	Mean ± S.D	P-value
CBL	46.8±33.4	**0.007**
Power point	55.6±26	
White board & Anatomical Models	59.4± 26.6	

Table II: Perceptions of students towards the three teaching methods along with statistical significance as calculated by one way ANOVA

Question	Mean marks awarded by students for each question			P-value
	CBL	PowerPoint	White Board with Models	
1.With which method lectures/content was organized and structural?	2.49	3.52	4.54	**0.00**
2. Which method was clearer regarding the lecture/contents?	2.56	3.55	4.47	
3. Clarity of new terms and spelling was better with which method?	2.65	3.70	4.08	
4. Clarity of diagram was better with which method?	2.06	4.02	4.15	
5. Method which increased the visibility of lecture/content?	2.51	3.66	4.41	
6. Which method had more understandable and better pronunciation?	2.82	3.52	4.36	
7. Which method was more interest stimulating?	2.92	3.26	4.58	
8. Which method had more reproducibility of text and diagram	2.45	3.68	4.37	
9. In which method you were able to take my notes/diagrams more easily?	2.79	3.52	4.25	
10. Which method was able to integrate text with figure in a better way?	2.27	3.93	4.26	
11. Which method had better continuity of previous knowledge/lecture?	2.57	3.67	4.62	
12. Overall satisfaction and effectiveness.	2.71	3.56	4.65	

Table III: Comparison of Significance Between the three teaching methods as calculated by Post -Hoc Tuckey-HSD

(The questions with significant p-values as calculated by One Way ANOVA are shown only)

Statements	Board vs CBL	Board vs Power point	CBL vs Power point
3. Clarity of new terms and spelling was better with which method?	0.000	0.20	0.000
4. Clarity of diagram was better with which method?	0.000	0.78	0.000

7.Which method was more interest stimulating?	0.000	0.000	0.23
9. In which method you were able to take my notes/diagrams more easily?	0.000	0.11	0.09
10. Which method was able to integrate text with figure in a better way?	0.000	0.233	0.000

Discussion:

The current research aimed to evaluate the relative effectiveness of three methods of instruction, PowerPoint presentation, whiteboard with anatomical models, and case-based learning (CBL) in Anatomy teaching from the perspective of 1st year MBBS students. Two primary parameters were considered: academic achievement (MCQ test scores) and students' perception of clarity, engagement, and satisfaction in each approach. The results demonstrated that whiteboard anatomy teaching supported by anatomical models was an optimum approach resulting in both the greatest academic success and highest positive perception, whereas CBL scored lowest across performance and many perception metrices, despite its accepted instrumental role in providing a deeper level of clinical reasoning.

Comparison of Academic Performance Across Methods

Both whiteboard & anatomical models were more successful than PPT or CBL in conveying the anatomical concepts to students. This is consistent with evidence from its use in other courses, where direct visual interactive teaching was reported to enhance understanding of Anatomy concept. Traditional board-based teaching provides live annotation of text and diagrams, instantaneous explanation of student questions, and the capacity to gradually build complexity over time; all characteristics that cannot be reproduced in static slide decks. Although sparse, recent research reinforces the benefits of tactile or visual learning activities compared to simply receiving passive lecture-based instruction. For instance, a recent review on medical education approaches reported that interactive and multisensory techniques generally produce better student engagement and performance than lecture-only formats, although no single method consistently trumps others across disciplines. (12)

Similarly, the MCQ component had the lowest scores among CBL students. The understanding that CBL improves clinical reasoning and higher cognitive capacities should be weighed against the possibility of it negatively affecting short-term performance in conventional academic tests. According to recent meta-analyses, the case based learning approach seems to be no more advantageous than traditional methods for recalling factual knowledge, particularly when learners are at the novice stage and the content is high in cognitive load, as is generally true of gross anatomy (8,12) This might account for why learners in our study had difficulty with MCQs under CBL, where the emphasis is on clinical application as opposed to recall of individual structural facts.

Student Perceptions: Clarity, Continuity, and Engagement

Performance data are supported by student perception data as well, with higher scores for whiteboard & anatomical model teaching across continuity of knowledge, clarity of new terms, diagram clarity, and overall satisfaction. These findings are consistent with recent educational studies of Anatomy teaching which have suggested the importance of interactive tools which facilitate the real time construction and verbal reinforcement of spatial relationships. For example, evaluations of new generation digital resources compared with traditional methods demonstrated that students perceived interactive resources as being enhanced tools for visualization and understanding of Anatomy but that the traditional methods continued to be important in providing scaffolding for basic knowledge. (3,13)

PowerPoint ranked second in appearance merits, including a clear view of images and content, in line with other studies demonstrating that slide-based learning can support the structure of content, such as teaching by presentation and display where visual clarity is significant. Yet static slides might miss the depth and interactivity necessary for moving beyond superficial conceptions in Anatomy. (12)

This was surprising, as CBL had lower rating points for clarity and ease for taking notes but some students regarded it as exciting. This is consistent with the wider literature on education that finds that CBL promotes engagement and autonomy of learners, but is still more effective when used in conjunction with other techniques or where students have basic content knowledge. (14) For instance, studies combining CBL with flipped classroom methods or didactic presentations have found better outcomes in clinical scenarios, suggesting the necessity of a scaffold approach prior to integrating CBL. (14)

Implications for Curriculum Design

The differences in outcomes between modalities have a number of implications for the design of Anatomy curricula:

1. Traditional methods of teaching, such as whiteboard and model-based demonstrations continue to have an important place in early medical education. These techniques seem to provide the most straight forward pathway for constructing a structural understanding and linking 2D and 3D presentations of human Anatomy.
2. Microsoft PowerPoint and related slide-based apps serve as a helpful medium for supporting structured information delivery and increasing visual clarity, but are less effective for interactive learning approaches in Anatomy.
3. CBL and similar student-centered approaches should be implemented gradually, optimally following mastery of the basics or as a supplement to clinical application rather than the primary way in which content is first encountered. It has been reported that the performance of students is better with combined CBL and flipped classroom or supplementary didactic teaching, indicating a blended approach may be utilized to its potential level in teaching Anatomy. (14,15)

Limitations and Future Directions

A significant shortcoming of the present study is the fact that it only considered a short duration

(2 weeks) and a single intervention measure, making it difficult to generalize results to long-term retention or clinical use. Longitudinal effects of these acts of teaching, such as retention over months and performance in clinically-based assessments, could be investigated in future studies. Furthermore, the use of recent modern interactive media such as 3D visualization, augmented reality or new teaching platforms such as digital Anatomy may offer a greater understanding of how traditional and innovative resources can work together to enhance outcomes. Recent research in this field indicates that interactive and digital tools lead to greater levels of student satisfaction and perceived learning, although the effects on long-term recall are somewhat varied. (13)

Declarations

Ethics approval and consent to participate This research was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethics Committee of HITEC-Institute of Medical Sciences. Informed consent to participate was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Dr Maleeha Zafar conceived the study, designed the methodology, and drafted the manuscript. Dr Iram Tassaduq, Dr Shaheer Abdullah, Dr Asma Hafeez, Dr Iram Zakria, and Dr Salma Shahab participated in data collection, facilitated the teaching sessions, and assisted in data analysis. All authors reviewed the results, contributed to the discussion, and approved the final manuscript.

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