Research Article

# Implementation of Image-Based Objective Questions As An Assessment Tool in Anatomy in Phase I MBBS Students

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**Abstract**

**Background:** Image-based objective questions (IBOQs) have emerged as a promising assessment strategy in anatomy by promoting visual interpretation, spatial understanding, and clinical application. However, evidence regarding their educational effectiveness and stakeholder acceptability remains limited.

**Objectives:** To evaluate students' and teachers' perceptions of image-based assessments, compare student performance across two image-based examinations, and assess the feasibility of integrating IBOQs into formative assessment for Phase I MBBS students.

**Methods:** A quasi-experimental study was conducted among Phase I MBBS students using routine formative assessments administered through Google Forms. Two examination sessions comprising text-based and image-based objective questions were conducted after an orientation session. Student performance was analysed using paired and independent t-tests, while perceptions of students and faculty were explored using Likert-scale questionnaires, thematic analysis of open-ended responses, and focus group discussions.

**Results:** Students scored significantly higher in text-based than image-based examinations in both assessment sessions. However, among the 86 students who completed both image-based assessments, mean scores improved significantly from 13.02 to 14.49 ($t = -3.20$, $p = 0.0019$), indicating adaptation to the assessment format. Qualitative findings revealed that IBOQs enhanced spatial understanding, clinical reasoning, integration of theory with dissection, and student engagement. Both students and faculty recommended gradual integration of image-based questions alongside conventional assessments while highlighting the need for structured practice, high-quality image banks, and appropriate digital infrastructure.

**Conclusion:** Repeated exposure to image-based formative assessments significantly improved student performance and promoted deeper, clinically relevant learning. IBOQs should complement, rather than replace, conventional text-based assessments to strengthen competency-based anatomy education.

**Keywords:** Image-based objective questions (IBOQs); Anatomy education, Formative assessment; Visual learning; Clinical reasoning; Student perception; Faculty perception; Online assessment.

## Introduction

The cognitive theory of multimedia learning advocates that during instruction, students comprehend better when text and images are combined rather than from words alone, processing information through separate auditory and visual channels. [1] While images have been preferred in anatomy teaching from time immemorial, their role in assessment and gauging students' performance remains inconclusive. [1, 2]

Assessments in anatomy witnessed an accelerated shift towards online examinations after the COVID-19 pandemic, highlighting the need for innovative formats. [2] Incorporating images (of prosected specimens, radiographs, histology slides, and clinical cases) aims to enhance the quality of questions, encouraging learners towards higher-order cognition such as application & evaluation. [3] Moreover, such questions can be administered to a vast population of students multiple times (reproducibility), in different settings, thereby addressing the issue of shortage of cadavers and wear and tear of prosected specimens (leading to distortion of the structure) due to repeated handling. [4]

Despite these theoretical advantages, evidence regarding the effectiveness of image-based questions in anatomy assessment remains inconsistent. Previous studies have reported variable effects on student performance, with some demonstrating improved achievement while others found no significant difference compared with conventional text-based questions. Furthermore, most available research has focused primarily on cognitive outcomes, with limited exploration of learners' and faculty members' perceptions regarding the acceptability, feasibility, and educational impact of image-based assessments. Consequently, there

remains a need for context-specific evidence to guide the meaningful integration of image-based objective questions into undergraduate anatomy assessment within Competency-Based Medical Education. This project innovates by systematically evaluating the impact of image-based objective questions (IBOQs) and further analysing students' as well as teachers' perceptions, acceptability, feasibility, and long-term influence on learning outcomes.

Since the advent of medical schools, anatomical education has depended heavily on cadaveric dissection and text-based assessments. After the COVID pandemic, reliance on digital platforms has increased, and new innovative assessment methods are gaining importance. Magi et al. demonstrated that first-year medical students performed better in image-based objective questions compared to text-only questions, with students reporting improved clinical reasoning and retention. [2] Sagoo et al. also found that students did significantly better in clinically oriented questions with images than without. [1] Similarly, Narnaware reported that inclusion of images in nursing anatomy examinations improved overall recall and performance. [5]

Conversely, Vorstenbosch et al. highlighted that item difficulty varied depending on type of image, signifying that validity may be affected. [6] Bahlmann found no significant differences in difficulty between illustrated and non-illustrated objective questions. [7] Holland et al. emphasized that images must be essential to the question; redundant images merely increase extraneous cognitive load without aiding retrieval but agreed that images influence reasoning processes even when item statistics remain unchanged. [8] Heidger et al. demonstrated that virtual microscopy could complement traditional methods without reducing performance. [9] Inuwa et al. reported that although better specimen quality (image) led to better time management in online examinations over traditional steeplechase formats, a drawback arose; these influenced students to study less from cadavers. [4] Bond et al. confirmed that online spotters are a reliable and valid alternative to traditional methods, maintaining feasibility and fairness. [10] Gross et al. demonstrated that integrating image-based active learning exercises into anatomy teaching significantly enhanced student examination performance. Student participation in image-based activities showed a positive correlation with performance in both image-based and text-based examination questions even after controlling for demographic variables and prior academic achievement. Students also perceived image-based activities as helpful for visualizing key concepts and reported that these exercises required less mental effort than text-based activities. The authors concluded that combining visual material with active learning strategies promotes deeper understanding of anatomical concepts and supports the development of lasting mental models, making image-based learning particularly beneficial in anatomy education. [11] Narayanan and Ramakrishnan emphasized that anatomical images are indispensable in teaching because they improve visualization of spatial relationships, enhance memory retention, and facilitate meaningful learning when combined with appropriate multimedia and cognitive load principles. They recommended using high-quality, clinically relevant images with minimal unnecessary text, consistent orientation, appropriate visual cues, and sequential labelling to reduce extraneous cognitive load and improve comprehension. The authors further suggested incorporating three-dimensional, dynamic, and clinically contextual images to promote conceptual understanding, student interaction, and higher-order cognitive processing. These strategies provide practical guidance for effectively integrating image-based teaching and assessment in anatomy education. [12]

However, certain clinicians, surgeons, and anatomists consistently warrant the continued central role of cadaveric learning while advocating the cautious integration of modern imaging technologies in anatomy education. Ross et al. emphasized that cadaveric dissection provides irreplaceable hands-on experience with three-dimensional anatomical relationships, exposes students to normal anatomical variation, and fosters professionalism and empathy; hence, digital resources should complement rather than replace dissection. [13] Similarly, Sheikh et al. reported that most surgeons considered cadaveric/prosection-based teaching the most effective method of anatomy education and recommended greater integration of computed tomography (CT) imaging alongside traditional teaching to strengthen anatomical understanding. [14] Wainman et al. further demonstrated that although virtual and mixed reality technologies offer realistic and portable learning environments, physical models produced superior anatomical learning outcomes, highlighting the critical importance of stereopsis and authentic three-dimensional visualization in anatomy education. [15] Overall, evidence suggests that image-based examinations enhance engagement and authenticity, but outcomes depend on image type, context, and preparation.

So, the present study has planned to assess the impact of Image-Based Objective Questions as an Assessment tool in Anatomy in Phase I MBBS students

**Objectives**

- To analyse students' attitudes and perceptions towards inclusion of image-based questions in assessments.
- To analyse teachers' attitudes and perceptions towards inclusion of image-based questions in assessments.
- To compare the performance outcome of students across two image-based examinations.

## Methodology

- **Design:** Quasi-controlled study.
- **Participants:** Phase I MBBS students (Universal sampling with a minimum of 100students in each session).

- **Assessment Tools:** Objective examinations were conducted as part of routine formative assessment for MBBS Batch 2025 through Google Forms. The syllabus comprised Anatomy competencies taught in February, March, and April. [18]

**Question Types:**

- Multiple choice or multiple grid type (text-only and image-based questions)
- Text-only objective questions.
- Image-based questions (digitised images of real-life projected specimens, radiographs, histology slides, clinical cases, i.e., same material used in teaching).

**Example of image-based and text-based questions:**

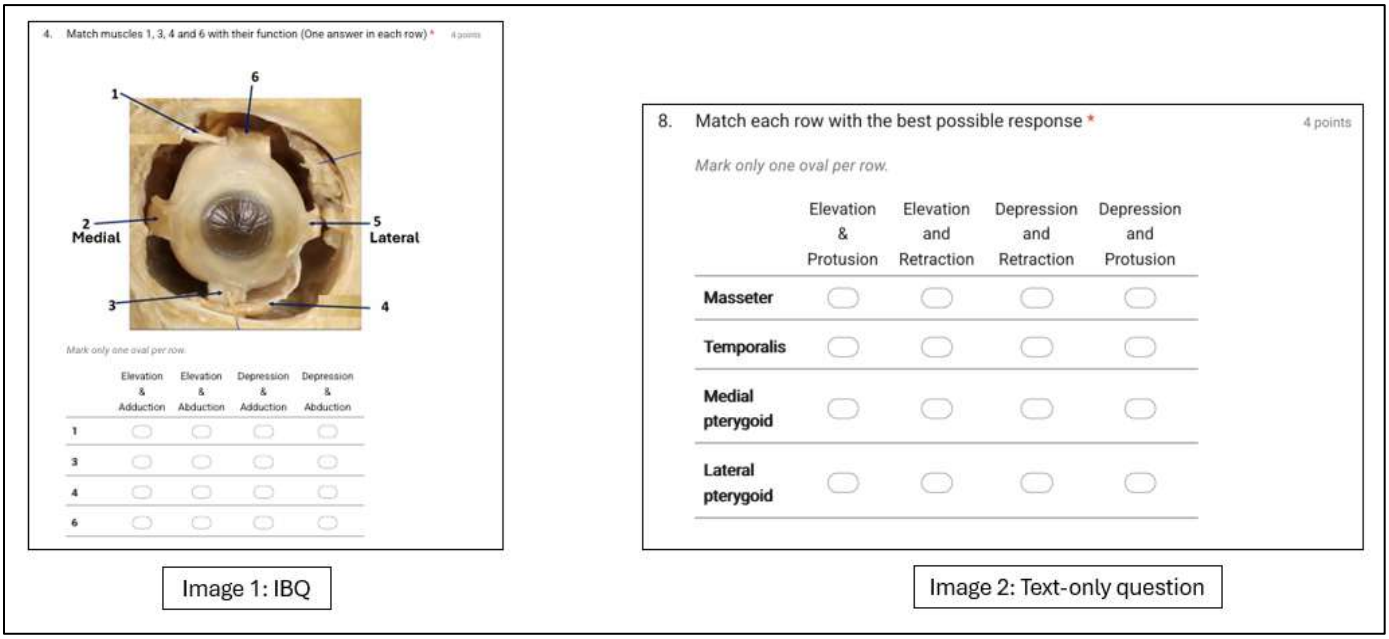



Image 1: IBQ

Image 2: Text-only question

Both questions assess the student's knowledge of muscle function. However, in the image-based question, the student must first identify the muscle and recognize its anatomical location before determining its function. The visual image can help students associate the muscle's function with its location in the orbit, thereby testing both anatomical identification and functional understanding. In contrast, the text-based question requires only the recall of the muscle's function from memory, without the need for anatomical identification or spatial interpretation.

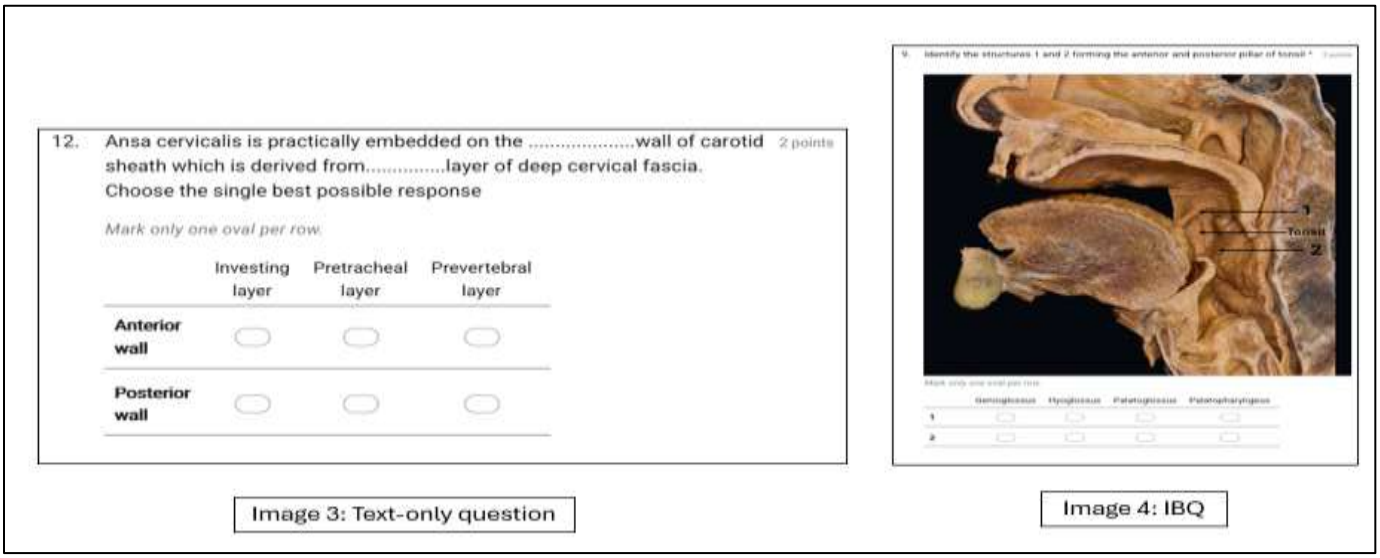



Image 3: Text-only question

Image 4: IBQ

Both questions assess the student's knowledge of anatomical relationships in the neck. In the image-based question, the student must first identify the anatomical structures (the anterior and posterior pillars of the tonsil) on a cadaveric specimen before selecting the correct muscles. This requires visual recognition, spatial orientation, and application of anatomical knowledge. The image helps students relate the muscles to their actual anatomical position around the tonsil. In contrast, the text-based question primarily assesses factual recall of which layer of the deep cervical fascia forms the carotid sheath and the wall on which the ansa cervicalis is embedded.

**Procedure:**

- After getting the approval from the Institutional Ethical Committee vide letter no IEC/FMHS/2026-15 Dated: 09/03/2026, the faculty members and students were sensitized regarding the inclusion of image-based objective questions in formative assessment.
- A sample examination session was conducted for all students. The session was of 20 minutes, with two Google Forms (10min for each form), Form-1 with only text-based objective questions and Form-2 with only image-based objective questions. Maximum marks for each form were 10. There was no negative marking.
- The questions were validated for content coverage by three faculty members.
- Two examination sessions were then conducted. Each session was of 30 minutes, with two Google Forms (15min for each form), Form-1 with only text-based objective questions and Form-2 with only image-based objective questions. Maximum marks for each form were 20. There was no negative marking.
- Spacing between examinations was > 2wks. Students were informed of the date & syllabus of examination > 2wks in advance.

- **Feedback questionnaire**
- Consent was taken from faculty members and students. (Annexure 1)
- Feedback (Annexure 2) was taken from faculty members and students after the completion of the second examination session
- Feedback was designed to assess the merits, demerits, perceived quality, fairness, feasibility, potential for application and integration of image-based questions in assessment from both the learners' and the educators' perspective.
- Participants' anonymity was ensured to foster honest feedback.
- **Focus Group Discussion (FGD)**: One FGD session each was conducted with a group of 6 students and 6 facilitators. These qualitative sessions aimed towards a deeper thematic understanding of the innovation's acceptability and perceived impact on learning**.**

**Outcome Measurement**

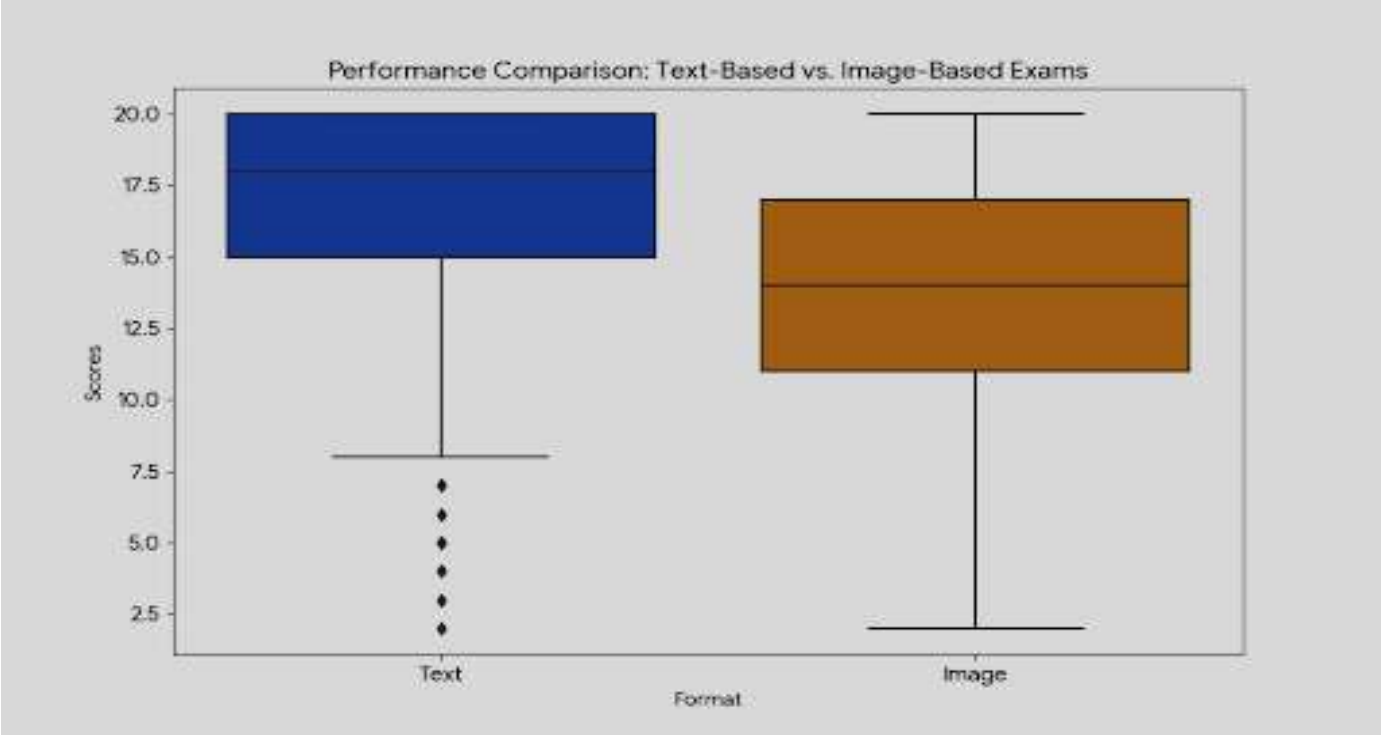
- **Quantitative Analysis:** Mean scores of text-only and image–based questions were compared using a paired t-test.
- **Qualitative Analysis:** Thematic analysis
- Analysis of students' perceptions towards inclusion of image-based questions in assessments was done by Frequency distribution of Likert responses.
- Analysis of teachers' perceptions towards inclusion of image-based questions in assessments was done by Frequency distribution of Likert responses.
- For merits and demerits of text-based and image-based question formats, thematic analysis of open-ended feedback was done.
- Thematic analysis of focused grp discussion was done.
- **Tools:** SPSS/Excel for statistical analysis.

## Results

**Quantitative analysis:**

**1. Descriptive Statistics:** The test distributions highlight a notable difference in average performance across the two formats:

- **Test 1:**
- **Text-Based Format:** Average score was 16.31 out of 20 across 146 responses.
- **Image-Based Format:** Average score was 12.94 out of 20 across 146 responses.
- **Test 2:**
- **Text-Based Format:** The average score was 16.89 out of 20 across 146 responses.
- **Image-Based Format:** The average score was 14.05 out of 20 across 86 responses.



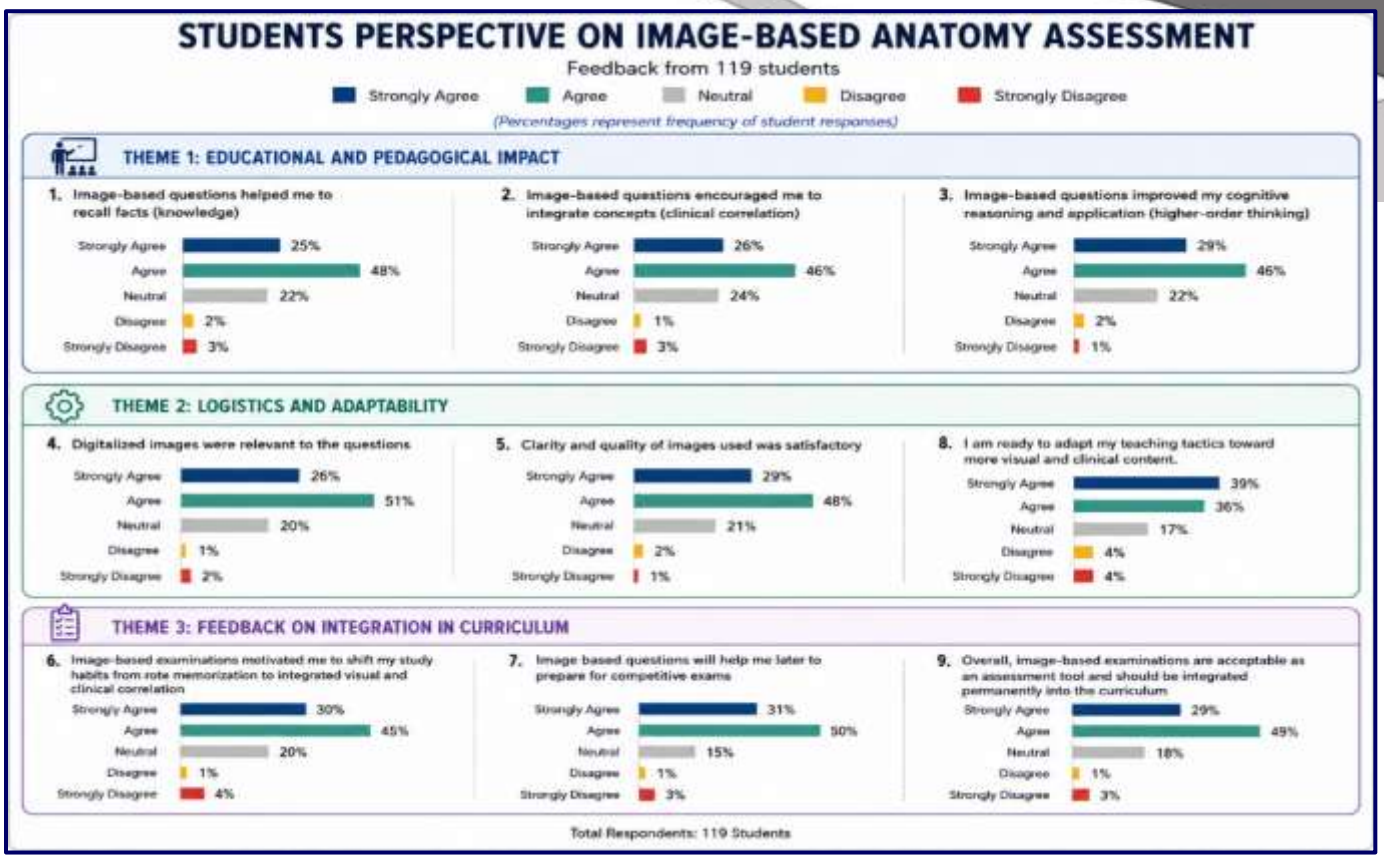

**2. Statistical Comparison (T-Tests)**

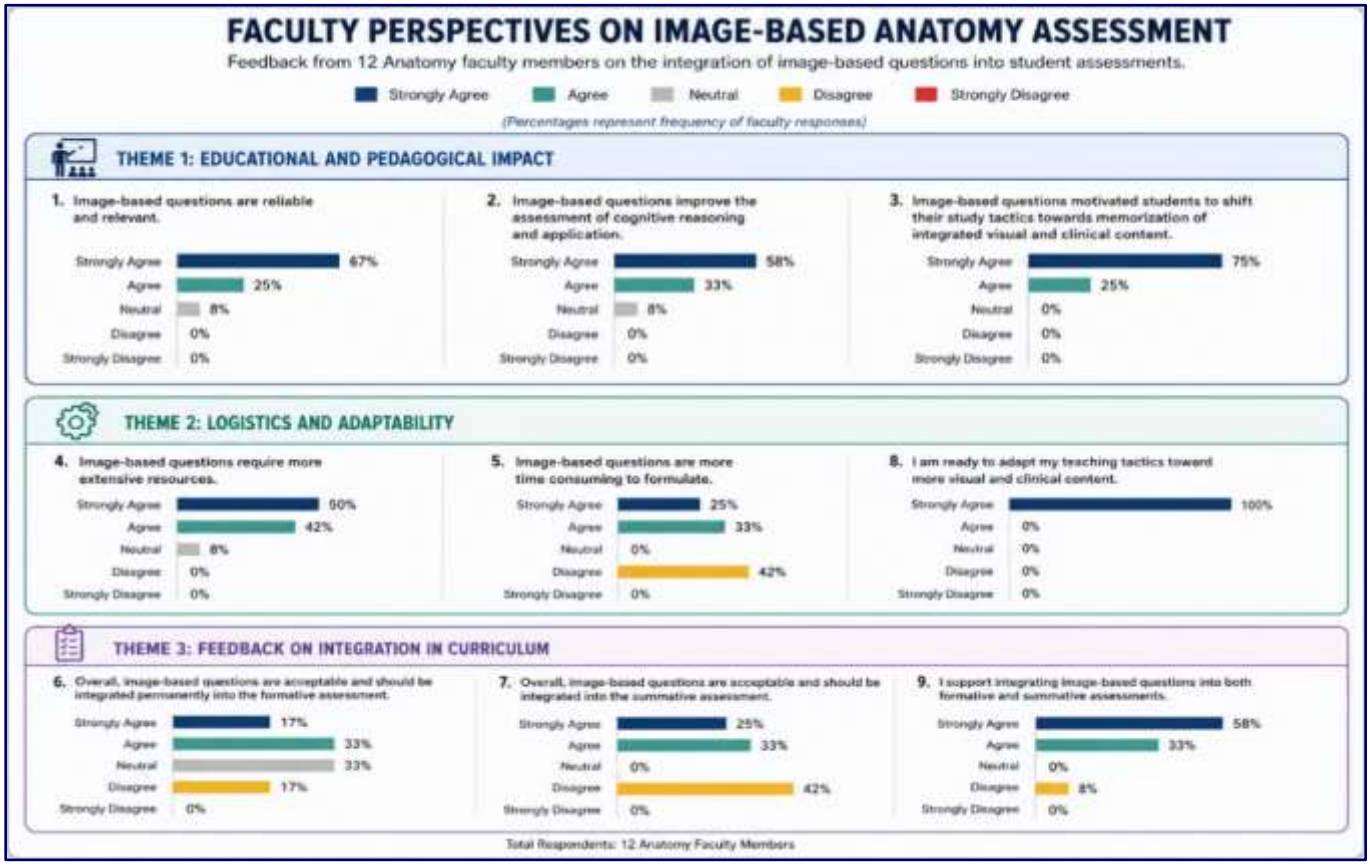
- **Test 1 (Paired T-Test):** The t-statistic is 7.06 with $p = 6.41 \times 10^{-11}$
  - **Conclusion:** The p-value indicates a highly significant statistical difference. Students performed significantly better in the text-based format for Test 1.
- **Test 2 (Independent Welch's T-Test):** The t-statistic is 4.89 with $p = 2.02 \times 10^{-6}$
  - **Conclusion:** Similar to the first test, this result is highly significant, confirming that the text-based format yielded substantially better outcomes on Test 2.
- **Overall Aggregate Comparison:** Combining all 292 text-based scores and comparing them to all 232 image-based scores via an independent t-test yields a (t-statistic of 8.70, $p = 4.64 \times 10^{-17}$).

**3. Performance Outcomes & Student Distribution:**

- **High Achievers vs. Struggling Students (Test 1):** On the text-based exam, 25 students achieved a perfect score of 20. Furthermore, only 6 students scored below **50%**. Conversely, the image-based exam saw a significant increase in lower scores, with 28 students falling below **50%**.
- **Score Clustering:** In the text-based exam, the maximum number of students grouped at the higher end of the scale. In the image-based exam, the scores shifted left, with the largest group consisting of 18 students who scored exactly 13 marks. This was closely followed by 14 students who scored 11 marks.
- The analysis conclusively shows that students performed better on text-based questions than on image-based questions in this dataset. The text formats not only resulted in significantly higher mean scores, but they also produced more perfect scores and drastically fewer failing grades compared to the image-based formats.
- The performance of students in the two image-based examinations was compared using a paired t-test. Among the 86 students who completed both assessments, the mean score increased from 13.02 in the first examination to 14.49 in the second examination. This improvement was statistically significant ($t = -3.20$, $p = 0.0019$), demonstrating a significant enhancement in students' performance following repeated exposure to image-based assessment. The findings suggest that familiarity with image-based questions improves students' visual interpretation skills and application of anatomical knowledge.

**Qualitative analysis:**




**Thematic Analysis**

**Theme 1: Educational & Pedagogical Impact**

- Enhanced spatial understanding through visual stimuli and image interpretation.
- Promoted higher-order cognition, clinical reasoning, and application of basic science knowledge to case-based scenarios.
- Increased student engagement and active participation by integration of theory with practical sessions, dissection, and demonstrations.
- Shifted learning from rote memorization to atlas-based learning, leading to longer retention
- Encouraged the faculty members towards integration of images and clinical correlations into routine teaching.
- Improved relevance of assessments by aligning with competency-based learning outcomes.

**Theme 2: Logistics & Adaptability**

- Students perceived difficulties included image interpretation, spatial orientation, and increased response time as key difficulties.
- Technical issues like internet speed and strength, screen size, and image clutter were recognized as potential hurdles that affected performance.
- Adaptability improved with repeated exposure to the IBOQ assessment format. Structured practice will help develop familiarity, eventually leading to improvement in response time and interpretation of images.
- Students favoured large-screen projection to improve image interpretation and reduce academic dishonesty during assessments.
- Faculty identified development of high-quality image banks as resource- and time-intensive activity.
- Question design and standardization required considerable faculty effort.
- Faculty recommended gradual implementation with regular practice for students

**Theme 3: Feedback on Integration in Curriculum**

- Strong consensus from both faculty and students that IBOQs should complement, rather than replace, conventional text-based formative assessments.
- IBOQs were perceived (by students) to strengthen competency-based learning and readiness for image-intensive computer-based examinations.
- Recommended integration of high-quality, real-life specimen images into routine teaching and formative assessments**.**

## Discussion

CBME, introduced by the Medical Council of India in the 2019 curriculum, aimed to transform the medical education system through a competency-based approach. However, the COVID-19 pandemic exposed significant gaps, highlighting the need for structural changes to address the practical challenges faced by medical teachers. [16]

E-assessments are a key component of e-learning and serve the same critical role as traditional assessments in supporting student learning. [17] The present study evaluated the educational impact of repeated image-based objective questions (IBOQs) as a formative assessment strategy in undergraduate anatomy. In the present study, the students achieved significantly higher scores in text-based questions during both assessments. The literature also does not show a universal score advantage from images alone, because some studies found no significant difference in item difficulty or discrimination between illustrated and non-illustrated questions (2,4). The most important finding was the significant improvement in image-based examination scores during the second assessment. This quantitative improvement was accompanied by measurable changes in students' learning behaviour and was consistently supported by the perceptions of both students and faculty. These findings indicate that repeated image-based formative assessment serves not only as an assessment tool but also as a catalyst for meaningful learning by encouraging integration of theoretical knowledge with cadaveric dissection, atlas-based learning, demonstration sessions and clinical application. While previous studies have primarily compared student performance between text- and image-based questions, the present study demonstrated that repeated exposure enables learners to adapt to image-based assessments and progressively improve their performance through changes in learning strategies (7,8).

The significant improvement observed during the second image-based assessment appears to have resulted from a combination of educational and practical factors. During the first examination, students encountered a relatively unfamiliar assessment format requiring interpretation of anatomical structures and their spatial relationships before answering clinically oriented questions. Unlike conventional MCQs, image-based questions demanded visual recognition, orientation, and application of anatomical knowledge, making them more cognitively demanding. Students openly acknowledged that they had never previously prepared for such examinations and initially found them challenging because they were accustomed to identifying keywords in text-based

questions rather than interpreting real anatomical images. Initial technical issues, including slower image loading, smaller mobile phone screens, and limited familiarity with the online platform, further contributed to the lower performance during the first assessment. By the second examination, these barriers had substantially diminished as students became familiar with the examination format and increasingly attempted the assessment on tablets or laptops, allowing clearer visualization of anatomical structures and easier interpretation of images. More importantly, the first image-based examination itself appeared to change the way students learned anatomy. Instead of relying predominantly on textbook reading and memorisation, students described deliberately modifying their study strategies after recognising the demands of image-based assessment. Several participants reported revisiting anatomical atlases, correlating two-dimensional atlas images with three-dimensional prosected specimens and paying greater attention during dissection demonstrations. One student reflected that before the intervention, "theory and practical were two segregated platforms," whereas image-based assessment encouraged integration of both learning experiences. Another explained that she deliberately compared multiple atlases before attending demonstrations to improve understanding of spatial orientation. Many students also reported concentrating on anatomical relationships rather than memorising isolated facts, while some intended to continue allocating a substantial proportion of their study time to atlas-based learning because visual memory improved recall and long-term retention. These behavioural changes provide a plausible explanation for the significant improvement observed during the second image-based assessment and suggest that formative assessment successfully directed learning towards deeper understanding rather than factual recall. These observations are consistent with the educational principles proposed by Schnotz, who described meaningful learning as an active integration of verbal and visual information into coherent mental representations (3). Initially, students experienced greater cognitive load because they had to interpret unfamiliar anatomical images while simultaneously applying their knowledge. However, repeated exposure appeared to reduce this cognitive burden as students gradually developed more effective visual schemas. Similar findings have been reported by Sagoo et al., who demonstrated superior performance in clinically oriented anatomy questions containing images (1), and by Magi et al., who observed that image-based MCQs stimulated clinical reasoning, analytical thinking and application of anatomical knowledge (2). Unlike these studies, the present investigation demonstrated lower initial image-based scores, probably because students were unfamiliar with this assessment format. Nevertheless, the significant improvement during the second examination suggests that familiarity and repeated practice are essential for realising the educational benefits of image-based assessment. The qualitative findings strongly reinforce this interpretation. Students repeatedly stated that image-based examinations encouraged understanding rather than memorisation. Several admitted that before this intervention they largely "mugged up" theoretical facts without appreciating their clinical relevance. Following the first examination, they consciously focused on anatomical relationships, spatial orientation and clinically important structures during demonstrations because they anticipated similar questions in future assessments. One participant explained that reviewing atlas images before demonstrations enabled her to ask more meaningful questions during practical classes, while another reported browsing clinical images after studying anatomy because visual correlation improved understanding. Students also appreciated that the examination used actual prosected specimens rather than idealised textbook illustrations, making the assessment more authentic and closely aligned with practical learning. These responses demonstrate that repeated image-based assessments promoted self-directed learning, clinical correlation and integration of theoretical and practical anatomy. Faculty observations independently confirmed these changes in student behaviour. Teachers consistently noticed greater student engagement during practical sessions following the first image-based assessment. Students participated more actively during demonstrations, asked more clinically relevant questions and frequently photographed well-dissected specimens for later revision. Faculty members believed that these behaviours would improve long-term retention because students were learning with greater interest rather than preparing solely for examinations. Several teachers also recommended incorporating more images of prosected specimens into routine lectures and tutorials to reinforce visual recognition before assessment. Many anticipated modifying their own teaching by including additional specimen photographs, radiological images, image-based discussions and low-stakes quizzes throughout the academic year. These observations indicate that image-based assessment influenced not only student learning but also faculty teaching practices, thereby strengthening constructive alignment between teaching, learning and assessment. Despite the improvement in image-based performance, text-based questions continued to produce significantly higher scores. Students explained that they had been solving conventional text-based MCQs throughout their school education and competitive entrance examinations and therefore possessed well-developed strategies for recognising keywords and eliminating distractors. In contrast, image-based questions required an additional step of identifying structures before applying anatomical knowledge, making them more time-consuming, particularly during the initial assessment. Another possible explanation emerged consistently during the focus group discussions. Students, faculty members, and invigilators believed that conventional text-based online questions were comparatively easier to search using split-screen functions or internet resources, whereas image-based questions required immediate interpretation of anatomical structures and therefore reduced this possibility. Since academic dishonesty was not directly measured, this explanation should be interpreted cautiously. Nevertheless, these perceptions suggest that image-based questions may provide a more authentic measure of students' understanding because they assess interpretation rather than simple retrieval of information.

Similar observations have been reported by Holland et al., who emphasised that images should be essential to answering the question so that they promote genuine cognitive processing rather than superficial cueing (8). Bond et al. likewise concluded that image-based online anatomy assessments provide a fair and robust method for evaluating practical anatomical knowledge (10). The practical implementation of image-based assessment was viewed positively despite several logistical challenges. Students initially identified internet connectivity, image loading time, smaller mobile screens and occasional image clutter as barriers to interpretation. However, these problems were substantially reduced during the second assessment, and many students recommended using larger screens such as tablets, laptops or smart-board projection for future examinations. Faculty members recognised that developing high-quality image-based assessments requires considerable effort in obtaining well-dissected specimens, capturing standardised photographs and constructing valid questions. Nevertheless, they believed that establishing a departmental image bank would reduce future workload while improving standardisation and assessment quality. Similar implementation challenges and solutions have been described by Inuwa et al. (4), who highlighted the logistical advantages of digital practical examinations despite their initial preparation demands, and by Heidger et al., who demonstrated that digital imaging effectively complements traditional anatomy teaching without compromising educational outcomes (9). An important finding of the present study was the strong support from both students and faculty for integrating image-based questions into routine formative assessment. Neither group advocated replacing conventional text-based questions. Instead, both recognised that text-based questions remain important for assessing theoretical understanding, whereas image-based questions uniquely evaluate visual recognition, spatial orientation and clinical application. Students expressed willingness to continue image-based formative assessments because they believed these examinations motivated them to remain engaged during demonstrations and atlas-based learning. Faculty similarly recommended gradual incorporation of image-based teaching, discussions, and quizzes throughout the curriculum to improve familiarity before higher-stakes assessments. This balanced approach is consistent with the recommendations of Bahlmann (7), Holland et al. (8) and Bond et al. (10), who advocate using image-based assessment to complement rather than replace traditional written examinations.

## Conclusion

Repeated image-based formative assessment improved students' image-based performance and encouraged integration of textbook knowledge with dissection, atlas study, and clinical reasoning. Faculty also noted greater student engagement and potential changes in teaching practices. Thus, image-based objective questions should complement conventional assessments in competency-based anatomy curricula to strengthen visual interpretation, theory–practice integration, and long-term learning.

### Limitations

The study was limited by its single-centre design, small number of assessment sessions, and potential effects of device and internet variability on image interpretation. Academic dishonesty was not directly assessed. Future multicentric studies with larger cohorts and longer follow-up are needed to evaluate long-term retention, clinical reasoning, and examination performance. Standardised image banks and reliable high-resolution assessment platforms may further improve the effectiveness and integrity of image-based assessments.

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