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ORIGINAL ARTICLE

# TECH-SPOT: Evaluating the feasibility and challenges of a technology-enhanced approach for spotting and assessing anatomical structures in medical education



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## KEYWORDS

Image-based spotters;  
Traditional spotters;  
Anatomy;  
Formative assessment;  
Technology

## Summary

**Introduction.** – In practical anatomical examinations, Spotters are used for real-time assessment. This method involves predissected specimens with structures pinned or tied. While it is suitable for small groups, it is challenging for large groups. To address this, we propose using “Technology-Enhanced Anatomy Spotters”, i.e., “Image-Based Spotters”, for formative assessments.

**Objectives.** – To explore students’ and faculty’ perceptions of the “Technology-Enhanced Anatomy Spotters” approach and identify challenges in its conduct.

**Methods.** – An image-based spotter session was organized for 250 first-year medical undergraduate students. The session involved the use of images of dissected specimens, histology slides, embryological models, and radiographic films. The PowerPoint presentation was prepared with one question per slide, with timed slide transitions. The response sheets were provided online via Microsoft Forms. The students’ and faculty members’ feedback was collected through a semistructured questionnaire and analysed both quantitatively and qualitatively. Qualitative data were analysed across three domains: session usefulness, difficulties/challenges encountered, and potential for further improvement.

**Results.** – A high level of satisfaction was observed, with 79% of the students and 77% of the faculty reporting that the ‘Image-based Spotters’ were conducted smoothly. However, only 16% of the students perceived it as a viable alternative to traditional real-time spotters. All faculty members (100%) reported evaluating online response sheets easier than hard copy submissions.

**Abbreviations:** MCQs, Multiple-choice questions; NMC, National Medical Commission; CBME, Competency-based Medical Education; TL, Teaching–Learning; LMS, Learning Management System; OSPE, Objective Structural Practical Examinations; TOSSPE, Tablet-assisted objective structured spotter practical examination.

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*Conclusion.* – The use of “image-based spotters” for assessing practical anatomy was well received by students and could prove to be a potentially useful method for formative assessments in practical anatomy for large groups. Furthermore, it can be of great use in instances of distant education and pandemic situations. However, careful consideration of technical issues such as virtual hindrances and logistics is necessary.

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## Introduction

Compared with instructional delivery methods, assessments of anatomy play a crucial role in learning and have been proposed to hold greater significance in student learning [1].

Practical examination in Anatomy employs ‘Spotters’ as a part of real-time assessment [2–6]. It includes a stream of prosections with structures pinned or tied in predissected specimens. It also includes histological slides, embryological models, and radiological films. This measure is in routine practice during summative assessments (i.e., end block, sessional, and end-year examinations), where a small group of students is assessed at a given time.

In the undergraduate medical curriculum, gross anatomy, histology, and embryology are traditionally taught as distinct subdisciplines. However, they are integrated during both the learning and assessment phases under a unified anatomy framework. Spotter examinations in routine practice inherently adopt this integrated approach by including specimens, histological slides, embryological models, and radiological images within a single assessment format. The present study adopts this blended approach to reflect the authenticity of existing assessment practices and to evaluate the feasibility of technology-enhanced spotters in a manner that aligns with routine summative examination settings rather than isolating discipline-specific outcomes.

‘Spotting’ is a term used in medical and anatomical education to describe the identification and labelling of anatomical structures on cadavers or anatomical models [7].

Spotter examinations are widely employed in anatomy, providing an avenue for assessing specific learning goals that are challenging to evaluate through written exams. For instance, objectives involving verbs such as find, identify, locate, recognize, and label can be more efficiently appraised in a spotter examination [1,2].

The spotter examination is a station-based evaluation wherein students encounter specific questions about a prosection, model, or medical image at each station. Typically, lasting one minute, each station comprises a basic or fundamental identification query and a question designed to assess higher-order thinking on the basis of Bloom’s taxonomy (i.e., functional/developmental/clinical/evolutionary aspects) [2,8,9].

The role of a spotter is crucial in anatomical education, as it helps students understand the three-dimensional spatial relationships between different anatomical structures, their functions, and their clinical significance. Hence, this approach surpasses the efficacy of using multiple-choice questions (MCQs) alone [4,10,11]. Spotters help students learn and reinforce their understanding of the structures and relationships of the human body [6]. They help test students’ knowledge of structural relationships, the ability

to differentiate between similar structures and the recognition of anatomical variants [1,2,12]. This practical approach is fundamental for healthcare professionals to develop a strong foundation in anatomy [13]. Therefore, spotter examinations are widely used and regarded as effective and practical methods for assessing anatomical knowledge, particularly for evaluating identification skills, spatial relationships, and applied understanding in anatomy [2,14].

It is used as an inclusive model in gross anatomy practical examination. The conduct of spotters is reliable and internally consistent and has fair validity, variable educational impact, and sustainable resource intensiveness [3–5].

Like any form of assessment, spotters have certain limitations. For instance, they can incur significant costs in terms of specimen preparation, resource usage, staff time, and workload [15]. It has also been observed that spotters primarily assess the lower levels of Bloom’s taxonomy (i.e., recall type) [13,14]. Additionally, grading hard copies of handwritten responses can pose challenges [15].

The National Medical Commission (NMC) of India has mandated the implementation of a competency-based medical education (CBME) curriculum, which emphasizes frequent formative assessments (continuous internal assessment) to enhance teaching–learning (TL) practices and promote the assessment of higher levels of Bloom’s taxonomy. In this context, there is a growing need for assessment strategies that facilitate continuous learning, timely feedback, and progressive competency development.

Traditional spotter examinations, although widely used in summative assessments, are resource intensive and pose logistical challenges, particularly when implemented frequently for large student cohorts. Technology-enhanced approaches, such as image-based spotters, offer a feasible alternative by enabling scalability, efficient conduct, and rapid feedback. These approaches may also support the assessment of higher cognitive domains, including comprehension, application, and analysis [2,16], while accommodating larger groups of students within the evolving CBME framework.

Furthermore, formative assessment settings provide a low-stakes environment that is well suited for the introduction and evaluation of innovative assessment strategies, allowing for iterative refinement prior to their potential application in high-stakes summative contexts. In addition, such approaches may help address several challenges associated with traditional spotters, including resource constraints and operational limitations.

Therefore, we propose the implementation of a technology-enhanced approach for conducting formative assessments in anatomy for large student groups, supported by appropriate digital infrastructure. This initiative, termed “TECH-SPOT” (Technology-Enhanced Spotting of

Anatomical Structures), aims to explore the feasibility and challenges associated with the conduct of 'Image-Based Spotters' from both student and faculty perspectives.

In the context of evolving competency-based medical education (CBME), there is an increasing need to explore feasible, scalable, and pedagogically sound approaches for conducting formative assessments in large student cohorts. While traditional spotter examinations are widely used, their adaptation to technology-enhanced formats requires systematic evaluation, particularly in terms of feasibility, user perception, and implementation challenges. Although image-based assessments of anatomy have been previously described, there remains limited evidence on the structured implementation and evaluation of technology-enhanced spotters in large-scale formative assessment settings. Therefore, the present study adopts an exploratory approach to examine the implementation and evaluation of a technology-enhanced, large-scale formative spotter model integrated within the CBME framework.

The present study therefore aims to explore the feasibility, perceptions, and implementation challenges associated with the use of technology-enhanced image-based spotters in the formative assessment of anatomy among undergraduate medical students.

## Materials and methods

The present educational intervention study was conducted during a formative assessment session in Anatomy for first-year medical undergraduates. The sample size comprised 250 students in batch 2023 (based on complete enumeration data) and nine-anatomy faculty. The institutional ethics committee approved the conduct of the study [IEC1:350/2023] (Annexure 1).

### Construction of the 'Image-based Spotters'

Images of the dissected specimens, histology slides, embryological models, and radiographic films were used to construct the spotters. The inclusion of images from gross anatomy, histology, embryology, and radiology was intended to mirror the integrated structure of conventional spotter examinations conducted in summative assessments, where these domains are assessed collectively rather than in isolation.

Images were selected to ensure adequate resolution and clarity, with emphasis on the appropriate orientation and visibility of key anatomical structures. The structures to be identified were marked by pointers, and relevant questions were tagged to them. The questions were framed on the basis of the different levels of the cognitive domain (Bloom's taxonomy) [7]. The open-ended questions had a primary or fundamental identification query and a question designed to assess higher-order thinking on the basis of Bloom's taxonomy (i.e., functional/developmental/clinical/evolutionary aspects) [2,8,9]. Fifteen spotter questions were designed, including five from the recall, comprehension, and analysis levels (Annexure 2). The subject matter experts in Anatomy vetted the spotter questions. The difficulty level of the questions included in the 'Image base spotters' was similar to that of the traditional real-time spotters. The spotters were

prepared in a PowerPoint presentation with one spotter per slide. The slide transition was timed automatically for one minute.

### Conducting 'Image-based Spotters'

The 'image-based spotters' were conducted after the traditional spotter's examination of the same batch of students. Traditional spotters involving real specimens/slides were previously used in the dissection hall.

During the session, the students were provided with response sheets online via the "Learning Management System" (LMS), which were accessible on their mobile phones, iPads/tablets, or laptops. Students without access to digital devices were permitted to answer on paper sheets. These sheets were later scanned and uploaded to the LMS. The spotters were projected on a large screen in the lecture hall (Fig. 1). The responses were subsequently evaluated online by the faculty. Following the completion of the test, the facilitators discussed the answers with the students in the lecture hall.

The session was conducted simultaneously in two large groups of 125 students, each with adequate spacing. The entire session was conducted under the supervision of the faculty (session facilitators) to avoid distractions. After the session was completed, a validated semistructured questionnaire was distributed to assess the students' and faculty members' perceptions of the session (Annexures 3 & 4).

### Session evaluation

The session effectiveness was evaluated on the basis of the first level of the Kirkpatrick evaluation model [17].

Following the educational intervention, the students and faculty were invited to answer self-developed and validated semistructured questionnaires on the program's usefulness.

The semistructured questionnaires used in the study were developed on the basis of a review of the relevant literature and the objectives of the study. Content validity was established through expert review by faculty members in anatomy and medical education, who assessed the relevance, clarity, and comprehensiveness of the items. The questionnaire was further refined on the basis of their feedback. Pilot testing of the instrument was conducted on a small group of students to ensure clarity and feasibility, and minor modifications were made accordingly prior to its final administration.

Separate questionnaires were administered to students and faculty online via Microsoft Forms after informed consent was obtained (Annexures 3 & 4).

### Data analysis

The quantitative data were analysed with SPSS 26 (IBM, SPSS, Inc.). Quantitative data were analysed using descriptive statistics, including frequencies and percentages. Measures of central tendency were calculated where appropriate. Given the exploratory nature of the study, no inferential statistical tests were performed.

Qualitative data obtained from open-ended responses were analysed using a thematic analysis approach, guided



Figure 1 Excerpts from the conduct of 'Image-Based Spotters'.

by the framework proposed by Virginia Braun and Victoria Clarke [18]. The responses were initially reviewed independently by three authors (SP, ADS, LA) to achieve familiarization with the data and to identify recurring patterns and concepts. Preliminary codes were then generated and iteratively refined through an inductive, semantic approach. These codes were subsequently organized into broader themes through collaborative discussion, with a consensus reached among the research team to ensure consistency and credibility in theme development.

## Results

### Student related findings

One hundred and four students (58 males and 46 females) out of 250 students consented to participate in the study. The age of the participants ranged between 18 and 23 years (mean age: 19).

Quantitative findings are presented first, followed by qualitative thematic observations.

#### Quantitative findings: learner satisfaction or reaction to the program

Students' perceptions of the usefulness of the session were assessed across the following domains: effective facilitation skills, effective assessment process, learning (assessment) climate/environment, learner needs, and learner satisfaction.

**Effective facilitation skills.** Most students reported that the session was well conducted, with 79% agreeing. However, perceptions regarding the ease of following the image-based spotters in the projected format were more varied, with only 41% agreeing, while a notable proportion expressed neutral or negative responses.

**Effective assessment process.** Students demonstrated mixed perceptions regarding the assessment component. While a substantial proportion agreed that the experience was comparable to slide-based histology spotters (65%), fewer students perceived it as equivalent to specimen-based gross anatomy spotters, with 63% expressing disagreement. Most students (73%) consistently indicated that traditional specimen/slide-based spotters were preferable to image-based spotters.

**Learning (assessment) climate/environment.** The learning environment and logistical arrangements were viewed positively. Most students agreed that the online response sheet was user friendly (75%), that the venue was appropriate (88%), and that the logistics were adequate (72%), indicating that the session was smooth.

**Learner needs.** With respect to learning support, 69% of the students agreed that the posttest discussion session contributed to improving their learning, highlighting its role in reinforcing understanding.

**Learner satisfaction.** Student confidence in performance during the session appeared variable, with only 19% reporting that they were able to perform well, while a considerable proportion remained neutral or disagreed.

The distribution of student responses across domains is illustrated in Fig. 2.

#### Qualitative findings

The responses to the open-ended questions were analysed thematically. An inductive and semantic approach was followed, and the following themes were derived.

**Theme 1: Enhancing learning through convenient and efficient image-based assessments.** The analysis of the open-ended question "What did I like about the session?" revealed the following.

Unlike the traditional specimen/slide-based spotters, the students stated that the 'Image-based spotters' were convenient in their conduct, with no hassle of moving from one

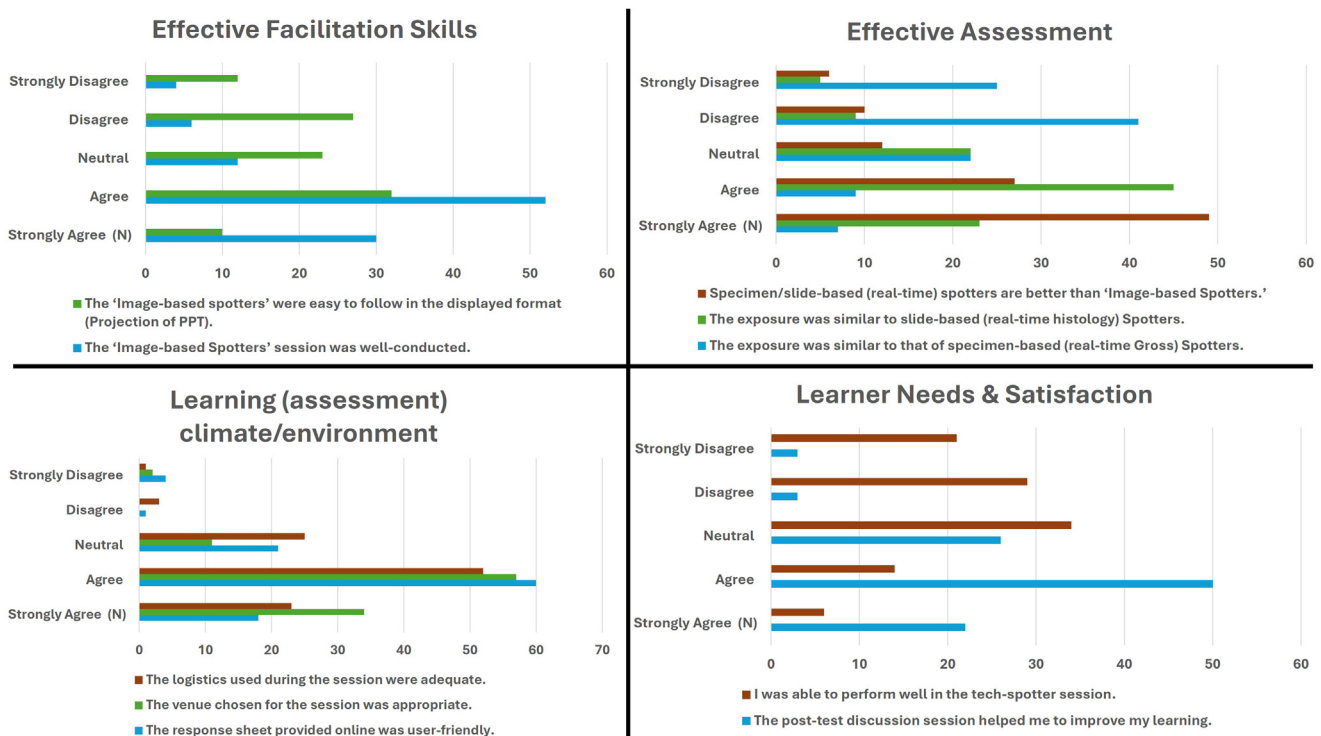


Figure 2 Graphical representation of the students' perceptions of the usefulness of the session.

place/station to another. The process was timesaving, and the students had sufficient time to analyse and answer every question. The images were clearly presented, as stated by the students, especially in Histology. The discussion of the answers that followed the conduct of the 'Image-based spotters' was much appreciated by the students. The students also added that similar tests should be frequently conducted, as they aid them in their learning process.

The subthemes identified were 'Convenient conduct', 'Great for revision', 'Time saving', and 'Image clarity.' A few responses are presented in Table 1. The responses are coded as UG STUDENT 1, 2, 3... , to mask the identifiers.

**Theme 2: Challenges in image-based spotters: the need for better visual orientation and 3d perspectives.** The analysis of the open-ended question "What were the challenges/difficulties?" revealed the following.

The students needed help to orient themselves with the images provided, especially those of the gross anatomy specimens. They reported that the images were zoomed in, focusing only on the intended structure rather than the entire specimen as in traditional spotters. Zoomed out, and pictures with complete orientation of the specimens were not provided. The images lacked a 3-dimensional view, and the spotting arrows needed to be more apparent to most students. Since the session was conducted in a lecture hall, unlike the traditional spotters conducted in the dissection hall with a stationwise approach, some students also faced visibility issues.

The subthemes identified were 'image clarity & orientation difficulty', 'lack of a 3-D approach', and 'impaired visibility' (Fig. 3). The responses supporting the themes are included in Annexure 5.

**Theme 3: Refining image-based spotters: balancing real-time benefits with digital innovation.** The analysis of the open-ended question "What could have been better OR can be further improved in the session?" revealed the following.

Most students vouched for the real-time spotters, stating that they provide a better orientation of the structures than 'Image-based spotters.' However, they also suggested that the conduct of the 'Image-based spotters' can be improved by considering the following:

- providing images of better clarity, exposure, and orientation;
- zoomed-in images should be supplemented with the actual image of the entire specimen, preferably with the orientation of the surfaces stated on the pictures;
- multiple images of the same specimen from different angles to provide a 3-D view may be considered;
- the use of cropped images should be avoided or improved.

Furthermore, the students suggested that 'image-based spotters' should be frequently used during formative assessment sessions as they aid their learning.

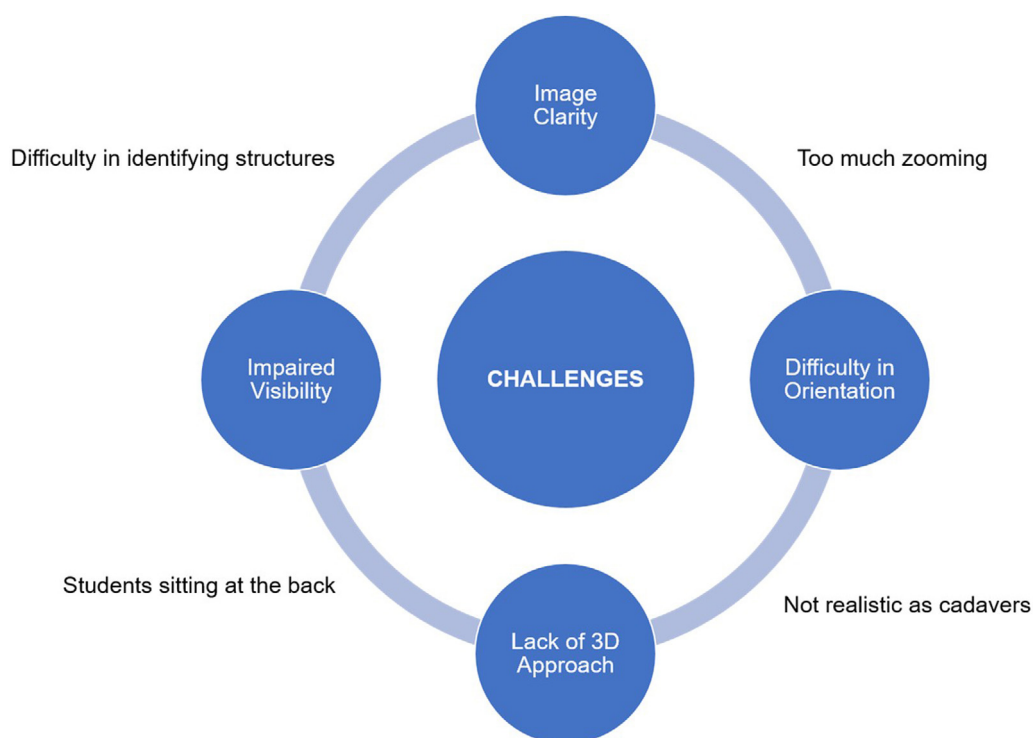
The subthemes identified were 'real-time spotters', 'clarity & orientation', and 'frequency conduct.' A few responses are presented in Table 2. The responses are coded as STUDENT A, B, C... , to mask the identifiers.

### Faculty-related findings

Nine faculty members (one male and eight females) involved in the conduct of 'Image-based spotters' and familiar with the conduct of the traditional spotters consented to be a

**Table 1** Representation of the responses by the students to the open-ended question “What did I like about the session?” along with the sub themes identified.

Sub themes	Corresponding responses
Convenient conduct	It was comparatively easy to follow. (UG STUDENT 1) It was a very convenient way to conduct spotters. (UG STUDENT 2) Appropriate time for spotting and answering no need to hassel. (UG STUDENT 3) I got an idea about what all questions can exactly be asked. More tests should be like this conducted. (UG STUDENT 7) The questions themselves were very helpful, and the presentation of questions on a projector was a good alternative. (UG STUDENT 12)
Great for revision	The choice of questions was really nice and covered a wide range of topics. It gave us an insight into the kind of questions we should expect, and the discussion of answers was also helpful. (UG STUDENT 5) I didn't know a lot of the spotters but taking this spotters was the right step in the right direction. It helped me get familiar with the questions and the methodology of the tests. I'm sure it will benefit me for my UNI practicals. (UG STUDENT 10) The teachers discussed the OSPE at the end, which was a good form of revision and helped us gauge our level of preparation. (UG STUDENT 13)
Time saving	It was just like the previous times, infact with the improvement that we didnt waste our time running from one spotter to another, it was really convenient, and also the images were very clear. (UG STUDENT 4) The discussion and convenience of not moving and being at one place. (UG STUDENT 9) It helped me narrow down the parts I still have not fully grasped. Plus, we had more time for each spotter as we were not moving from one spot to the next. (UG STUDENT 14)
Image clarity	Histology was fine rest spotters must be in real specimen. (UG STUDENT 6) It was smoothly conducted... the images very very clear and improved my learning. (UG STUDENT 8) The images were very clear and finding the structure was easier than in real time specimens. (UG STUDENT 11)

**Figure 3** Subthemes highlighting challenges in answering ‘image-based spotters’ exams by the students.

**Table 2** Representation of the responses by the students to the open-ended question “What could have been better OR can be further improved in the session?” along with the sub themes identified.

Sub themes	Corresponding responses
Real-time spotters	Take real time spotters. (STUDENT A) DH sessions only please. (STUDENT B)
Clarity & orientation	Exposure of photos, Better picture. (STUDENT C) 2 different angles for each spotter. (STUDENT D) Clearly show the image. (STUDENT E) Better clues given for orientation or give the orientation of the specimen. (STUDENT F) More images from different angles for the same question to give more of a 3D view. (STUDENT H) If the pictures were more clear and elaborated. (STUDENT I) Pictures could be zoomed out slightly to aid in orientation. (STUDENT J) Making the entire section visible. (STUDENT K) Cropped images should be improved. (STUDENT L) Please do not use cropped images. (STUDENT M) Pictures of specimen can be improved. (STUDENT N)
Frequent conducts	Please conduct more like these. Pls give answers. Send more before university exams. (STUDENT G)

part of the study. Their teaching experience ranged from 2–17 years (mean age: nine years).

### Quantitative findings

The faculty’s perception of the usefulness of the session and its components was assessed across the following domains: effective facilitation skills, effective assessment process, and learning (assessment) climate/environment.

*Effective facilitation skills.* Most faculty members perceived the conduct of image-based spotters as easy, with 77% expressing agreement. In contrast, a majority (67%) disagreed that setting up image-based spotters was cumbersome compared with traditional specimen/slide-based spotters, indicating relative ease in preparation and implementation.

*Effective assessment process.* Faculty responses indicated a generally favourable perception of the assessment potential of image-based spotters. A large proportion (89%) agreed that this format has the potential to support the assessment of higher levels of Bloom’s taxonomy. However, opinions regarding its appropriateness varied depending on the assessment context. While 44% considered it suitable for formative assessment, responses for summative assessment were evenly distributed, with equal proportions expressing agreement, disagreement, and uncertainty.

*Learning (assessment) climate/environment.* Compared with hard copy submissions, all faculty members reported that the evaluation of online response sheets through the learning management system was easier, reflecting a clear advantage in terms of assessment efficiency.

The distribution of faculty responses across domains is illustrated in Fig. 4.

### Qualitative findings

The analysis of the open-ended questions revealed the following.

*Theme 1: Image-based spotters in formative and summative assessments: efficiency vs. orientation challenges.* The

reasons for ‘image-based spotters’ being an appropriate tool for formative assessment were reduced manpower, good time management, real-time feedback, and a safe learning environment.

The reasons stated for the ‘image-based spotters’ not being an appropriate tool for formative assessment were lack of orientation and lack of exposure to specimens in real time.

The reasons stated for ‘image-based spotters’ being an appropriate tool for summative assessment were better clinical orientation and correlation.

The reasons stated for the ‘image-based spotters’ not being an appropriate tool for summative assessment were lack of 3D orientation and lack of exposure to specimens in real time (Annexure 6).

*Theme 2: Efficient and versatile: the role of image-based spotters in enhancing anatomy assessments.* Faculty agreed that the ‘image-based spotters’ were easy to conduct and assess. The process was timesaving and involved reduced utilization of resources. This venture will be good at times of resource constraints, i.e., nonavailability of specimens. Compared with traditional spotters, the session also requires fewer faculty members, and it can be conveniently conducted remotely (proctored online sessions) or in lecture halls involving few faculty members. Another feature highlighted was the versatility of its conduct. It is an ideal way of conducting spotters to assess all the aspects of anatomy, i.e., gross anatomy, embryology, histology, and radiology.

The subthemes identified were ‘Convenience conduct’, ‘Timesaving’, ‘Less manpower’, ‘Reduced resource utility’, and ‘Versatility’ (Fig. 5). The responses supporting the themes are included in Annexure 6.

*Theme 3: Challenges in image-based spotters: clarity, technical limitations, and faculty training.* The clarity in the images and lack of orientation were the significant challenges listed by the faculty. The quality of the pictures may vary when they are accessed on different devices, e.g., mobile phones, iPads, or tablets, by the students. They fur-

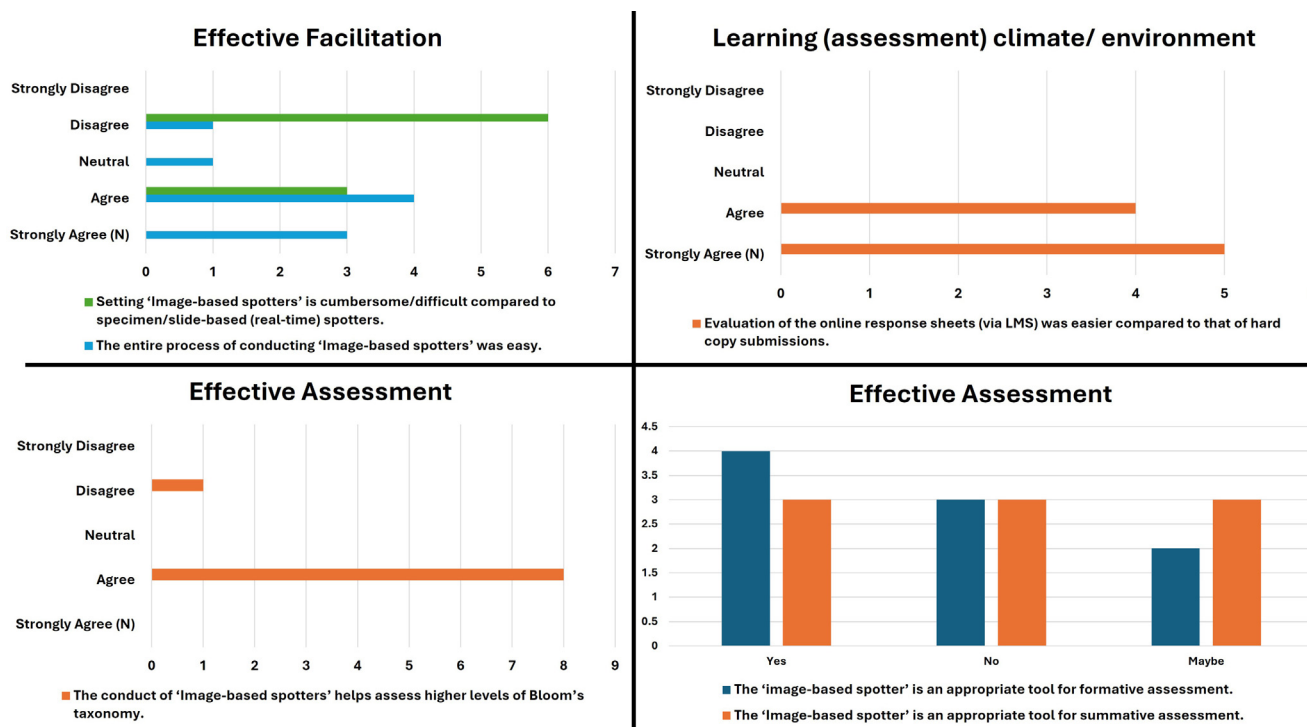


Figure 4 Graphical representation of the faculties' perceptions about the usefulness of the session and its components.

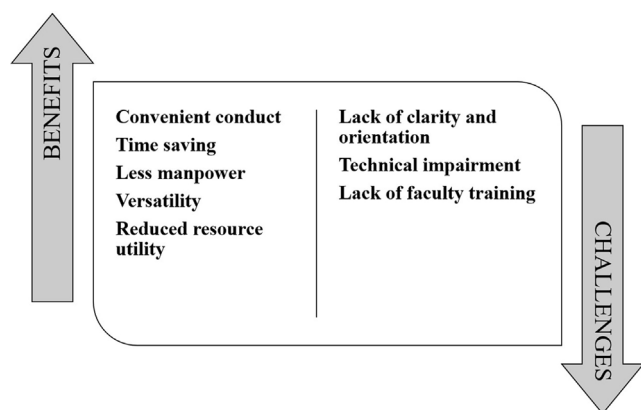


Figure 5 Major subthemes highlighting the benefits and challenges in conducting an 'image-based spotters' exam from the faculty perspective.

ther suggested that the images must be clear with better resolution and proper orientation and that the arrows must define the structures the students are expected to identify. Technical glitches that may have been encountered during the session were also listed as challenges. A lack of faculty training in conducting 'image-based spotters' may also hinder its implementation, as mentioned by the faculty.

The subthemes identified were 'Lack of clarity and orientation', 'technical impairment', and 'Lack of faculty training' (Fig. 3). The responses supporting the themes are included in Annexure 6.

*Theme 4: Advancing image-based spotters: enhancing visual clarity, integrating case-based learning, and building image repositories.* The faculty suggested that a larger view

of the images with indicators for anatomical planes and positions may be considered to improve the clarity and orientation of the images. Video and case-based questions may be incorporated to assess higher levels of learning. A standard repository of images may be created that can be utilized during the teaching–learning process, which can be used in such assessments.

The subthemes identified were 'improving image clarity and orientation', 'inclusion of videos and case-based scenarios', and 'creation of a repository of images.' The responses supporting the themes are included in Annexure 6.

## Discussion

### Role of assessment in learning and anatomy education

Assessment ensures that students attain a defined standard, allowing them to be deemed competent in that subject [19]. "Assessment drives learning" is a familiar dictum that indicates that assessment is pivotal in steering the learning process. The desired learning mode, whether surface, deep, or strategic, can be encouraged by employing appropriate learning opportunities and assessments to drive that specific form of learning [20].

The 'spotter' is an inclusive gross anatomy practical examination model. The conduct of spotters is reliable and internally consistent and has fair validity, variable educational impact, and sustainable resource intensiveness [14]. The technology-enhanced conduct of Anatomy spotters has the potential to support the assessment of higher levels of Bloom's Taxonomy (i.e. comprehension, application, and

analysis), and reach out to more students, enhancing their learning process in the current CBME curriculum [16]. The findings of the current study are similar.

The qualitative findings of the present study further highlight a nuanced perspective regarding the use of image-based spotters in anatomy assessment. Students largely appreciated the logistical ease, clarity, and time efficiency associated with the conduct of image-based spotters, particularly in the context of large-group assessments. Faculty members similarly perceived advantages in terms of ease of administration and evaluation. However, a recurring concern among students was the difficulty in understanding three-dimensional anatomical relationships when assessed through two-dimensional images, which affected spatial orientation and depth perception. This contrast between perceived logistical efficiency and challenges in spatial understanding underscores the complementary role of image-based and traditional spotters in anatomy education. These thematic findings should be interpreted in light of the qualitative approach adopted, which aimed to capture broad patterns in participant responses rather than perform an in-depth qualitative inquiry.

Spotters receive acclaim from educators and students who recognize that, despite being stressful, they represent the most effective method for testing anatomical knowledge [8]. The findings of the present study are in line with this observation, with the students being in favour of its conduct, stating that it is not only an exciting form of assessment but also helps them in their learning by providing a good amount of revision of the anatomical content.

### Technology-enhanced spotters in the context of contemporary literature

Recent studies in anatomy education and digital learning contexts support the evolving role of technology-enhanced assessment approaches in facilitating scalable and flexible learning environments [21–24]. Several studies have explored modifications to traditional and virtual spotter examinations aimed at enhancing the assessment of higher-order cognitive skills, particularly in response to evolving educational needs and the shift toward digital learning environments [15,21–24].

Most of the developments have occurred recently with the advent of the COVID-19 pandemic-induced lockdown and social distancing. Although technologically advanced, these measures differed from the ‘image-based spotters’ described in the present study.

Research conducted by Yaqinuddin et al. has explored implementing an integrated assessment approach in anatomy, combining fundamental sciences with clinical applications, as seen in Objective Structured Clinical Examinations (OSCEs). This integrated approach aims to evaluate applied anatomy in clinical settings, targeting the highest levels of learning taxonomies, particularly the application of knowledge [21].

The use of automated marking of spotter examinations, which requires students to complete an optically read mark sheet, has been introduced previously. The students were given a list of structures, with numbered items representing anatomical structures. These structures were to be iden-

tified or tagged during a laboratory and computer-based practical examination. This has resulted in a rapid return of marks and feedback to students, enhanced marking consistency, and reduced time spent grading each script for staff [22].

A new spotter format was designed for functional eye anatomy for first-year optometry students at the University of Manchester. Each student responded to three questions per specimen, with the answers corresponding to the labelled structures (A, B, C, or D). The challenge involved determining the solution and identifying the correct structure among the labelled options, eliminating the potential ‘cueing effect’ associated with typical multiple-choice questions or traditional spotters. The spotter format assessed comprehension rather than mere knowledge, streamlining the grading process by eliminating subjectivity. This led to a reduction in the time spent discerning the accuracy of the responses. It also promoted uniformity in grading and reduced the amount of time staff dedicated to marking each script. The drawback observed was that since students are not compelled to identify specific structures by name but are instead required to choose from answer options, they may need more familiarity with the anatomical names of the labelled structures [15].

### Digital and online assessment context (COVID-19 and beyond)

During the pandemic, when conducting practical examinations online was necessary, studies have stated that adequate training related to virtual assessments should be provided to students and faculty to ensure adequate preparedness to stay on par with global digitalization [23].

Online Objective Structured Practical Examinations (OSPES) using images (from photographic atlases) and/or videos of cadaveric materials were also conducted previously during the pandemic in medical schools in the UK. Conducting online exams posed challenges as students were taking them remotely, making it difficult for educators to monitor their activities. This resulted in inadequate exam security, allowing students to refer to external resources and download or copy questions and images. Additionally, it faced the drawback of limited access to properly regulated cadaveric material images, which constrained the exam content. This study highlights the need for robust measures to prevent students from accessing other resources during exams and the use of good-quality cadaveric images [24].

In light of these varied approaches and findings, the present study offers a distinct perspective by examining the structured implementation of image-based spotters within a formative assessment framework. While earlier studies have focused primarily on the use of images as an assessment tool, the present study extends this approach by evaluating the feasibility and challenges of implementing a structured, technology-enhanced spotter system in a large cohort within a formative assessment framework. Although ‘image-based spotters’ have been utilized in prior research, the current study differs in its use of open-ended questions, as opposed to the predominantly objective formats reported earlier. Furthermore, unlike remote assessment methods, the ses-

sion was conducted in a controlled lecture hall under faculty supervision, thereby minimizing the likelihood of students accessing external resources during the examination.

### Impact of image-based assessment on learning and performance

Research examining the influence of images on student performance in anatomy assessments provides clear insights, although findings vary across different questions and image formats. For instance, Vorstenbosch et al. reported that compared with a diagrammatic representation, incorporating cadaveric images in Anatomy exams using an extended matching format may heighten question difficulty. They advocated for further exploration of the impact of diverse image types on assessment outcomes [25]. In contrast, an investigation by Holland et al., which focused on multiple-choice-type histology questions, revealed no significant effect of images on exam difficulty or student performance [26]. Conversely, Sagoo et al. demonstrated that students performed better on 'Single Best Answer' style questions when accompanied by images than when not accompanied by images [27].

Ozen et al. compared students' scores in a laboratory spot test (shown in a 3D environment, also known as a spotter/classical/traditional/tag/ring/bell-ringer test) with those in a class slide test (utilizing gross anatomy images in a 2D environment). They concluded that the spot test is believed to gauge success or ability in a 3D environment, whereas the slide test assesses it in a 2D environment. In summary, neither of these examination types has a definitive advantage. Each has distinct characteristics concerning assessment power, applicability, and impact on success [28]. The results of the present study are the same, indicating that traditional spotters and 'image-based spotters' are beneficial as different assessment forms. While traditional spotters are more suitable for summative and formative assessments, 'image-based spotters' may be relevant as the choice of test during formative assessments.

### Technical considerations, spatial cognition and three-dimensional understanding during image-based spotters

Technical issues such as image clarity, orientation, and internet accessibility emerged as important considerations during the conduct of image-based spotters. In this context, the effectiveness of image-based spotters is closely influenced by the technical quality of the images used, including factors such as resolution, angulation, lighting, and clarity of anatomical landmarks. In the present study, efforts were made to ensure adequate image quality. However, challenges related to orientation and visualization of structures were noted, reflecting inherent limitations of two-dimensional representations in conveying three-dimensional anatomical relationships. Similar concerns have been highlighted in recent studies, which emphasize that limitations in image quality and a lack of depth perception may affect spatial understanding and accurate identification in anatomy learning and assessment [29,30].

One potential strategy to address these limitations is the incorporation of both overall views and focused close-up images of anatomical structures. Providing context alongside magnified perspectives may enhance spatial orientation and facilitate the integration of anatomical relationships, as supported by contemporary research on multimodal and visual learning approaches in anatomy education [30,31].

Beyond these technical considerations, the observed difficulty in spatial orientation can be further understood within the framework of spatial cognition, which is fundamental to anatomical learning. The ability to mentally reconstruct three-dimensional relationships from two-dimensional representations is a complex cognitive skill that varies among learners and is essential for accurate comprehension of anatomical structures [30,32]. The absence of true depth perception in image-based assessments may therefore limit students' ability to integrate spatial relationships effectively, particularly for clinically relevant anatomical understanding. This highlights the inherent challenge of translating spatially rich anatomical content into static two-dimensional images and reinforces the continued importance of complementary approaches that allow direct or simulated three-dimensional visualization [29].

### Higher-order cognitive assessment

Furthermore, the design of assessment items plays a crucial role in determining the cognitive level of learning being evaluated. In the present study, selected questions were designed to align with higher-order cognitive domains, such as application and analysis, in accordance with Bloom's taxonomy. While the structure of the assessment allowed for the inclusion of higher-order questions, the study did not directly measure the extent to which such cognitive engagement was achieved.

Recent literature indicates that image-based assessments can be effectively designed to evaluate higher-order thinking, including interpretation and clinical reasoning, beyond simple recall [25,33]. Examples of such higher-order questions are provided in Annexure 2, demonstrating the potential of image-based spotters to facilitate deeper learning.

While the current study focuses on formative assessment, future research may explore the validity, reliability, and applicability of image-based spotters in high-stakes summative settings.

### Acceptance and feasibility of image-based spotters

Online spotter exams with single best response types have also been conducted previously and are liked by students because they provide instant feedback and enhance learning [4,34]. Tablet-assisted objective structured spotter practical examination (TOSSPE) in Anatomy was also appreciated by the students [35]. Technical issues such as internet connectivity and software and hardware deficits were the major hindrances to online spotter exams [36].

Students have exhibited positive acceptance of online spotter assessment and other online or computer-based spotter formats, with expectations of further improvement as they become more accustomed to such methods [2].

Similar observations were made in the present study. The students and faculty, although they preferred the conduct of traditional spotters over 'Image-based spotters', did not oppose the latter's conduct. They welcomed the idea of conducting 'image-based spotters' as a helpful alternative. Despite the advantages of access to real-time specimens/slides, the requirement for a substantial number of academic staff members to examine simultaneously limited the feasibility of the traditional format to only small student cohorts.

Frequent conduct of traditional spotters during formative assessments may also not be feasible and turn out to be a burden for both faculty and students. Therefore, embracing the "image-based spotters" session, improving it, and conducting it along with the existing traditional real-time spotters will help align with contemporary online learning trends and the requirements of the competency-based medical curriculum. It can be a great form of revision, as proposed by the students. Furthermore, it can be highly important during instances of distance education and pandemic situations.

While the present study does not evaluate learning outcomes or directly compare the effectiveness of image-based spotters with that of traditional methods, it provides important insights into their feasibility, scalability, and practical implementation within a real-world educational setting. In the context of CBME, where there is a growing emphasis on frequent formative assessments for large student cohorts, such implementation-focused evidence is valuable. The findings contribute to the field by demonstrating how technology-enhanced assessment strategies can be operationalized, highlighting both their logistical advantages and their contextual limitations. These insights may inform the design and refinement of formative assessment practices, particularly in resource-constrained or high-volume teaching environments.

Recent studies in anatomy education and digital learning contexts further support the evolving role of technology-enhanced assessment approaches in facilitating scalable and flexible learning environments.

'Image-based Spotters' can serve as a potentially useful measure in the conduct of formative (continuous internal assessment) assessments during practical sessions in Anatomy for large groups of students, provided that the technical hindrances are adequately addressed. It can aid in enhancing student learning and engagement during formative assessments. Constructive student and faculty feedback will be utilized for further development, improvement, and standardization of the conduct of 'Image-based Spotters' in Anatomy. In parallel with CBME, attempts can be made to assess the higher levels of Bloom's Taxonomy using this method. Video-based, case-based/problem-based vignettes can be incorporated during the future conduct of 'image-based spotters.'

## Limitations and practical implications

The present study is exploratory in nature and focuses primarily on feasibility and participant perceptions. It does not evaluate objective learning outcomes or establish the validity of the assessment method. Future studies incor-

porating performance metrics, comparative designs, and validity frameworks are needed to better substantiate the effectiveness of technology-enhanced spotters in anatomy assessment.

The student response rate was approximately 40%, which may limit the representativeness of the findings and introduce potential response bias, as participants with stronger opinions may have been more likely to respond.

Although the students were exposed to both traditional spotters and image-based spotters, the study was not designed as a comparative investigation. Additionally, the absence of objective performance measures and within-subject comparisons limits conclusions regarding learning outcomes or assessment effectiveness.

Finally, the quantitative analysis was restricted to descriptive statistics without inferential testing, which may have constrained the depth of interpretation. Additionally, the qualitative analysis did not include formal validation procedures such as interrater reliability measures or external validation, which may limit the methodological rigor and credibility of the findings. Future research incorporating robust analytical approaches would provide more comprehensive insights into the educational impact of this assessment method.

## Conclusions

Image-based spotters can serve as a potentially useful approach for conducting formative assessments in anatomy, particularly for large student cohorts. Their feasibility, time efficiency, and ease of implementation make them valuable tools for content revision and for supporting student engagement and learning. However, their applicability in summative assessments remains limited, primarily because of constraints in representing three-dimensional anatomical relationships.

While both students and faculty tend to prefer traditional spotters for better spatial orientation, the frequent conduct of such assessments may be challenging, especially in resource-constrained settings. In this context, image-based spotters offer a practical and scalable alternative, with particular relevance in situations such as distance education and pandemic-related disruptions.

Constructive feedback from students and faculty can be utilized to further refine and standardize this assessment approach. Attention to image quality, orientation, and clarity is essential for optimizing its effectiveness. In alignment with the competency-based medical education framework, image-based spotters also hold potential for assessing higher-order cognitive domains within Bloom's taxonomy.

## Data availability statement

Availability of data and materials: the annexures, datasets generated and/or analysed during the current study are available in the [FIGSHARE] repository, [<https://doi.org/10.6084/m9.figshare.28211789>] [37].

Annexures:

- Annexure 1: Ethics Committee approval letter;

- Annexure 2: 'Image-based spotter' questions;
- Annexure 3: Questionnaire 1 (Students);
- Annexure 4: Questionnaire 2 (Faculty);
- Annexure 5: Students' responses to the open-ended question 'What were the challenges/difficulties?' related to 'Image-based spotters';
- Annexure 6: Faculty responses to open-ended questions;
- Additional File 7: Student feedback dataset;
- Additional File 8: Faculty feedback dataset.

## Ethics approval and consent to participate

The Institutional Ethics Committee approved the study [IEC1:350/2023 dated 13th September 2023]. The study was performed in accordance with the relevant guidelines and regulations laid out by the ethics committee. Informed consent was obtained from the participants before they participated in the study. Research was conducted under the ethical standards of the Declaration of Helsinki.

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## Author contributions

SP: conceptualization, methodology, data collection, formal analysis, investigation, writing – original draft, visualization; ADS: conceptualization, supervision, validation, writing – review & editing, correspondence, project administration; LA: data collection, data curation, formal analysis, writing – review & editing; AKP: methodology support, statistical analysis, interpretation of results, writing – review & editing; PLC: supervision, resources, critical review, validation, writing – review & editing.

## Sustainable development goals (SDGs)

This study aligns with SDG 3 (Good Health and Well-being; Target 3.c), SDG 4 (Quality Education; Target 4.3 and 4.7), and SDG 9 (Industry, Innovation and Infrastructure) by strengthening the quality, accessibility, and scalability of anatomy assessment through technology-enhanced approaches. The implementation of image-based spotters enables efficient formative assessment for large cohorts, optimizes faculty workload, and supports faculty capacity in delivering timely feedback, thereby contributing to health workforce development (Target 3.c). By promoting learner-centered, technology-integrated, and flexible assessment strategies that enhance the engagement and continuity of learning, including during remote or pandemic situations, the approach advances equitable access to quality medical education (Target 4.3) and fosters adaptive, innovative pedagogies (Target 4.7). Furthermore, the use of digital platforms and online evaluation systems exem-

plifies educational innovation and resilient infrastructure, supporting sustainable and scalable assessment practices, which are particularly relevant for resource-constrained and high-enrollment medical institutions.

## Disclosure of interest

The authors declare that they have no competing interest.

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