

## Perceptions of Phase-1 MBBS Students on Open Book (Resource) Formative Assessment in Enhancing Higher Order Thinking Skills

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### ABSTRACT

**Background:** Contemporary medical education emphasizes critical reasoning and knowledge application rather than rote memorization. Open-book formative assessments (OBFA) provide an authentic approach that fosters analysis, synthesis, and problem-solving. However, evidence on their role in enhancing higher-order thinking skills (HOTS) among Phase-1 MBBS students in India remains limited. This study explored student perceptions of OBFA in fostering HOTS and identified its perceived benefits and challenges.

**Methods:** A cross-sectional mixed-methods study using an explanatory sequential design was conducted among 137 Phase-1 MBBS students in Andhra Pradesh. Participants undertook both closed-book and open-book formative assessments in anatomy. Quantitative data from a validated questionnaire (Cronbach's  $\alpha = 0.707$ ) and qualitative data from ten focus-group discussions (7–8 students each) were analyzed using descriptive statistics, correlation, and Braun and Clarke's thematic framework.

**Results:** Mean scores improved significantly from closed-book ( $12.95 \pm 3.54$ ) to open-book assessments ( $18.41 \pm 2.07$ ;  $p < 0.001$ ). Students perceived OBFA as enhancing critical thinking (3.91), application of anatomical knowledge (3.99), and analytical integration (4.09). It reduced anxiety (3.82) and promoted self-directed learning (3.99). Perception of OBFA strongly correlated with analytical integration ( $r = 0.71$ ,  $p < 0.001$ ). Themes reflected a shift from memorization to conceptual learning, improved problem-solving, and reduced stress, though time constraints and resource management posed challenges.

**Conclusions:** OBFA fosters higher-order cognitive engagement, conceptual understanding, and independent learning among early-phase medical students. With appropriate orientation and faculty training, its integration with traditional methods can strengthen CBME-aligned assessment practices.

**KEYWORDS:** Open-Book Examination, Formative Assessment, Higher-Order Thinking Skills, Self-Directed Learning, Competency-Based Medical Education.

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### INTRODUCTION

Medical education is shifting from factual

recall toward developing critical reasoning, analytical thinking, and problem-solving skills

essential for clinical competence. Traditional closed-book examinations primarily test memorization, which may not adequately prepare students for real-life medical decision-making that requires the application and synthesis of knowledge. In contrast, open-book assessments (OBAs) enable students to access reference materials during examinations, emphasising comprehension, integration, and evaluation rather than rote reproduction.

During the foundational Phase-1 MBBS curriculum, covering anatomy, physiology, and biochemistry, students must develop the capacity to connect concepts across disciplines. Formative assessments, which provide feedback and promote learning, are valuable in this phase. Incorporating open-book formative assessments (OBFAs) may encourage higher-order thinking skills (HOTS), such as analysis, application, and synthesis, consistent with Bloom's taxonomy [1]. These cognitive processes underpin critical reasoning, clinical judgment, and evidence-based decision-making in later stages of medical training.

However, research on the effectiveness of OBFA in early medical education remains limited, particularly within the Indian context. Few studies have explored students' perceptions of OBFA and its potential to foster critical thinking, problem-solving, and self-directed learning. Additionally, qualitative evidence examining learners' experiences, challenges, and the contextual feasibility of OBFAs in resource-based settings is sparse.

Addressing these gaps, the present study investigates Phase-1 MBBS students' perceptions of open-book formative assessment in enhancing higher-order thinking skills, identifying its perceived benefits, limitations, and implications for integrating authentic, learner-centered assessment strategies in competency-based medical education (CBME).

## MATERIALS AND METHODS

### Study Design and Participants:

A cross-sectional mixed-methods study employing an explanatory sequential design was conducted among Phase-1 MBBS students at a rural medical college in Andhra Pradesh,

India. All 150 students were invited, and 137 participated, providing complete data.

**Educational Intervention:** Two formative assessments in anatomy were administered sequentially — one closed-book and one open-book formative assessment (OBFA). The closed-book assessment, conducted in May, comprised 10 multiple-choice and 3 short-answer questions (maximum score: 25) from the neuroanatomy module. The subsequent OBFA, held in June, followed the same structure but covered the abdominal region, with extended time (60 minutes) to accommodate resource consultation. Students were permitted to use standard anatomy textbooks and were briefed on examination procedures before implementation.

**Validation of Assessment Tools:** All assessment items underwent prevalidation by a panel of five subject and medical education experts. Each item was rated for relevance, clarity, and alignment with Bloom's taxonomy, yielding item-level content validity indices (I-CVI: 0.6–1.0) and scale-level CVIs (S-CVI: 0.8–0.86).

**Data Collection Instruments:** Quantitative data on student perceptions were collected using a prevalidated Likert-scale questionnaire (Cronbach's  $\alpha = 0.707$ ) containing items on critical thinking, problem-solving, and self-directed learning. Qualitative data were gathered through focus group discussions (FGDs) involving 7–8 students per group, stratified by performance level. Ten FGDs were conducted until data saturation, each lasting approximately 45 minutes, moderated by a trained facilitator unaffiliated with the assessments.

### Data Analysis:

Quantitative data were analyzed using descriptive statistics, independent t-tests, and Mann-Whitney U tests to explore gender differences. Pearson's correlation coefficients were calculated to examine relationships among key perception domains. Qualitative data were analyzed manually using Braun and Clarke's six-step thematic analysis framework, including familiarization, coding, theme generation, and validation through member checking and peer debriefing [2].

**Ethical Considerations:** Institutional Ethics Committee approval was obtained prior to data collection (Faculty/1285/25). Participation was voluntary, and confidentiality was maintained throughout the study.

## RESULTS

A total of 137 students responded to the questionnaire and have attempted both the exams. Thirteen students out of 150 were absent for one or more formative assessments. The majority had no prior exposure to open-book assessment. The internal consistency of the questionnaire or the Cronbach's alpha was 0.707, which shows the question items reliably measure a unified construct of student perceptions on OBFA. The number of female (92) students was more than male (45)

students. The t-value is -0.33, and the p-value was 0.745, with no statistically significant difference between male and female groups showing similar trends. Mann-Whitney's U test confirmed the same results of positive attitudes of both genders, with a U value of 2069.5 and a p value of 1. The near-identical results from both tests indicate gender neutrality in how students perceive open-book assessments. Both male and female Phase-1 MBBS students equally recognized OBFA's benefits in promoting understanding, critical thinking, and reduced anxiety. Mean score increased significantly from  $12.95 \pm 3.54$  to  $18.41 \pm 2.07$  (paired  $t = -9.33$ ,  $p < 0.001$ ), indicating substantial immediate learning gains during the open-book assessment.

**Table 1:** Shows the scores secured by students in the two formats of assessment.

Type Of Assessment	Maximum Score	Minimum Score	Mean score
Close book assessment	20	3	12.95 ± 3.54
Open-book assessment	22	11	18.41 ± 2.07

**Table 2:** Showing responses on perceived effectiveness of OBE compared to CBE.

Item	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean Score
Better Understanding of concepts OBE vs CBE	10.9	48.2	32.1	8	-	3.61± 0.82
Less anxious and stressful OBE vs CBE	27.7	46.7	8.8	13.1	-	3.82± 1.09
Understands topics better OBE vs CBE	10.9	42.3	29.9	16.8	-	3.47± 0.90
Actual learning happens with OBE vs CBE	21.2	56.2	10.9	10.9	-	3.86± 0.90

**Interpretation:** Students emphasised that they were less anxious during open book exam compared to close book, the feasibility of providing textbooks during exam seemed to create a less stressful environment. Students could comprehend actual learning happening during open book exam as to compared close book. Moderate scores and percentages were observed for conceptual learning and actual learning with OBE. But overall students inclined positively towards open book exam

**Table 3:** Shows the responses of students on impact of OBE on higher order thinking skills.

Item	Strongly agree	agree	Neutral	disagree	Strongly disagree	Mean score
Enhances critical thinking	20.4	56.9	16.8	-	-	3.91± 0.82
Promotes application of anatomy knowledge	21.2	60.6	14.6	-	-	3.99± 0.71
Analyse and integrate information	24.8	61.3	11.7	-	-	4.09± 0.67
Promotes problem solving	22.6	56.2	16.1	-	-	3.96± 0.77

**Interpretation:** Students responded well to statements which promoted higher order thinking skills with open book exam. Questions related to application of anatomical knowledge for clinical scenarios, analysis and integration of information were highly supported by the students. The mean scores on critical thinking and problem solving are also high, indicating that students perceived that open-book exams enhance higher-order thinking skills.

**Table 4:** Shows the responses on perceived challenges and benefits of OBE.

Item	Strongly agree	agree	neutral	disagree	Strongly disagree	Mean scores
Motivated and meaningful learning	13.9	51.8	21.2	12.4	-	3.66± 0.89
Time management issues	5.1	27	24.8	38	5	2.87± 1.04
Organising material was difficulty	15.3	47.4	24.8	12.4	0.7	3.65 ± 0.91
OBE promotes self-directed learning	21.2	60.6	15.3	-	-	3.99 ± 0.72

**Interpretation:** Students perceived that managing time during the open book exam was difficult followed by finding and organising the material during examination. Many students gave positive responses that OBE promotes self-directed learning and activates meaningful learning rather than rote memorisation. Although OBFA appears to strengthen both understanding and confidence, students may benefit from additional guidance, such as curated resource lists, orientation sessions, and strategies for effective time use. Overall, the results reflect strong support for integrating OBFA within the competency-based medical education (CBME) framework. Its focus on application, reasoning, and independent learning aligns well with the goals of producing reflective and competent future clinicians.

Correlation analysis demonstrated significant positive associations among all measured subdomains. Strongest correlations were observed between perception of OBFA and analytical integration ( $r = 0.71$ ,  $p < 0.001$ ), and between critical thinking and application of knowledge ( $r = 0.54$ ,  $p < 0.001$ ). These results suggest that favourable perceptions of OBFA are aligned with enhanced higher-order cognitive engagement and intrinsic motivation among Phase-1 MBBS students.

**Table 5:** Shows the summary of the correlational analysis of the subdomains of student responses.

Subdomain	Perceptions	Critical thinking	Application	Analysis & integration	Motivation for SDL
Perceptions	1	0.47	0.52	0.71	0.47
Critical thinking	0.47	1	0.54	0.5	0.49
Application	0.52	0.54	1	0.49	0.41
Analysis & integration	0.71	0.5	0.49	1	0.38
Motivation for SDL	0.47	0.49	0.41	0.38	1

The qualitative data collected in the form of verbal responses to the semi-structured focus group discussions were transcribed, and thematic analysis was done following the steps of the Clarke & Braun method. Credibility of data was maintained through member checking, where findings were taken back to students for accurate reflection of their perceptions. Peer debriefing duly done with other researchers to identify any other explanations accordingly. For consistency data saturation was observed till no new themes emerged, followed by manual coding by four trained researchers in qualitative data handling. After thorough manual coding, the following themes and subthemes were identified. The reflective responses of students in the form of quotations are tabulated below.

**Table 6:** Shows the themes and subthemes derived after thematic analysis.

Themes	Sub-Themes	Quotations
Perceptions on open-book exam	Expectations and reality	<i>"I thought it would be easy since the book was allowed, but actually, it requires practice."</i>
		<i>"I expected that I would find answers and copy from text textbook, but the questions have to be understood correctly."</i>
	Reduced Stress	<i>"I felt less stressed compared to closed-book exams." "OBFA reduced exam fear and helped me attempt with confidence."</i>
Modified learning approaches	Shift from Rote to Conceptual Learning	<i>"I focused more on concepts and understanding the topic" "I was trying to find answers, understand what I was reading, and then answered the questions."</i>
	Application of Knowledge	<i>"Some questions were case scenarios, so I had to connect different parts of the topic."</i>
	Promote problem-solving and critical thinking	<i>"I thought just naming structures was enough in anatomy, but I had to apply that knowledge."</i>
Benefits of OBE	Enhancement of learning	<i>"I could remember the material better because I applied what I read for the exam."</i>
	Promotes self-directed learning	<i>"It is better not to memorise; open open-book test is a good method for self-learning"</i>
Challenges of OBE	Time Management	<i>"Even though I had my textbook, I couldn't finish in time." "It was hard to quickly find what I needed in the book."</i>
	Information processing	<i>"I was not sure how to use the textbook effectively during open book exam".</i>
Preferences and suggestions	Balanced assessment	<i>"OBFA is good for formative, but university exams should be closed book". "I prefer both methods for learning a subject".</i>
	Need for training	<i>"If I had practiced in OBFA, I would have performed better". "More OBFA with more training, but both methods are good."</i>

## DISCUSSION

This study examined Phase-1 MBBS students' perceptions of open-book formative assessment (OBFA) and its influence on higher-order thinking skills (HOTS) using a mixed-method explanatory sequential design. The findings indicate that OBFA enhanced conceptual understanding, analytical reasoning, and integrative learning, while reducing examination-related anxiety. Students reported that open-book testing encouraged deeper engagement with study material and promoted reflective, self-directed learning. These results underscore OBFA's potential as an innovative assessment approach that aligns with competency-based medical education (CBME), which emphasises the development of cognitive flexibility, problem-solving, and lifelong learning habits.

Quantitative analysis demonstrated a significant improvement in mean scores from closed-book to open-book assessments, suggesting that access to learning resources facilitated a deeper understanding rather than superficial memorisation. The highest mean scores were recorded for statements related to comprehension and clinical application, emphasising that OBFA nurtures integrative thinking. The positive correlation between perception and analytical integration ( $r = 0.71, p < 0.001$ ) and between critical thinking and application ( $r = 0.54, p < 0.001$ ) supports the assertion that positive attitudes toward OBFA are strongly linked with enhanced cognitive performance and analytical skill development.

Qualitative findings complemented these quantitative outcomes. Students initially perceived open-book tests as easier, but later realised that the format required conceptual clarity, resource navigation skills, and effective time management. They reported a transition from rote learning to deeper engagement with anatomical concepts, finding the format more authentic and clinically relevant. OBFA was viewed as reducing anxiety and improving confidence, consistent with the view that formative, low-stakes assessments foster a psychologically safe learning environment. However, challenges such as unfamiliarity with

the method, limited time, and difficulty organising reference materials were recurring concerns, indicating a need for structured orientation before implementation.

The findings of this study align with earlier work by **Alghamdi et al. 2024 [3]**, who reported that 82.7% of medical students perceived open-book examinations (OBEs) as accurately reflecting their understanding, and over half credited OBEs with promoting self-directed learning. Similarly, **Mahmoudzah-Sagheb et al. 2015 [4]** found that 72% of students preferred open-book formats and experienced reduced stress and enhanced confidence. The present study extends these insights by showing that Indian Phase-1 students also perceive OBFA as fostering critical and integrative learning, although with moderate confidence—possibly due to their limited prior exposure to such formats.

**Dayananda et al. 2021 [5]** likewise observed that OBEs lowered stress and promoted self-directed learning, though some students doubted their role in enhancing logical reasoning. In contrast, the current study found stronger endorsement of OBFA's analytical benefits, likely because anatomy inherently lends itself to conceptual application. Furthermore, **Eldakhkhny et al 2024 [6]** reported that integrating team-based learning with OBEs improved critical thinking and engagement, echoing the current findings. While the present study did not assess psychometric indices such as difficulty and discrimination, it adds value through triangulation of quantitative and qualitative data, yielding a deeper understanding of learning behaviors.

The observed reduction in examination anxiety resonates with classic findings by **Feldhusen et al. 1961 [7]**, **Broyles et al. 2005 [8]**, and **Dale VH et al. 2009 [9]**, who established that open-book formats alleviate stress compared with closed-book exams. However, **Eilertsen and Valdermo 2000 [10]** cautioned that anxiety may persist if questions are complex or time is insufficient—an observation echoed in the current study. Students' time management difficulties highlight that OBFA demands prior training in resource utilisation and question interpretation.

The performance advantage observed in this study parallels that of **Agarwal and Roediger 2011 [11]** and **Skidmore and Aagaard 2004 [12]**, who found higher immediate test performance in open-book conditions. These benefits, however, depend on the depth of study preparation rather than the mere availability of materials. Conversely, **Jehu et al. 1970 [13]** and **Brightwell et al. 2004 [14]** found no significant differences between open- and closed-book formats for essay-type questions, suggesting that the type of assessment item plays a key role. The present study's inclusion of both MCQs and short-answer questions likely provided a balanced assessment of both recall and analytical skills.

OBFA's role in reducing stress and encouraging deeper learning is further supported by **Weber et al. 1983 [15]** and **Ben-Chaim and Zoller 1997 [16]**, who reported that take-home or open-resource exams reduced anxiety and enhanced engagement. Conversely, **Baillie and Toohey 1997 [17]** found that some students experienced comparable stress in both exam types, emphasizing that open-book formats are not inherently stress-free but depend on task design and preparation. In this study, students described OBFA as less stressful yet more intellectually demanding, indicating cognitive rather than emotional challenge.

From a pedagogical standpoint, OBFA aligns well with **Bloom's taxonomy** by moving assessment toward the higher cognitive domains of application, analysis, and synthesis. Bobby et al. 2018 [18] pointed out that open-book examinations (OBEs) are a worthwhile assessment tool for encouraging students' higher-order cognitive abilities. However, as noted by **Haladyna and Rodriguez 2013 [19]**, Hancock 1994 [20] and Martínez 1999 [21] designing MCQs that accurately measure these domains remains challenging. Future OBFA designs should therefore ensure that question formats target analytical reasoning rather than simple information retrieval [22].

The present findings reinforce that open-book assessments can enhance cognitive engagement and reflection, particularly when embedded within a supportive, feedback

oriented formative framework. While much prior research has compared OBEs and CBEs in terms of anxiety or performance, few have investigated their qualitative impact on students' metacognition and learning behavior. This study contributes uniquely by capturing rich qualitative narratives that illustrate how OBFA prompts self-directed learning and fosters connections between theory and clinical reasoning—key aims of CBME.

Despite its strengths, this study's limitations include single-institution sampling, potential response bias, and the absence of longitudinal data on retention or transfer of learning. Future research should explore multi-institutional contexts, include psychometric evaluation of item quality, and track how OBFA exposure influences performance in subsequent clinical courses.

Overall, this study provides strong evidence that open-book formative assessment can serve as an authentic, learner-centered strategy for cultivating HOTS in early medical education. When supported by adequate faculty development, student orientation, and systematic integration within the curriculum, OBFA has the potential to transform assessment from a summative endpoint into a dynamic learning experience that strengthens reasoning, reflection, and readiness for complex clinical problem-solving.

## CONCLUSION

This mixed-method study demonstrated that open-book formative assessment (OBFA) effectively enhances higher-order thinking skills (HOTS) among Phase-1 MBBS students within a competency-based medical education framework. Students performed significantly better in open-book tests, indicating improved understanding, analytical reasoning, and integrative learning. Perceptions and focus group insights revealed that OBFA fosters conceptual understanding, critical thinking, problem-solving, and self-directed learning while reducing examination anxiety. Qualitative findings highlighted a shift from rote memorization to meaningful, application-oriented learning, though

challenges such as time management and unfamiliarity with the format were noted. Overall, OBFA represents an authentic, learner-centered assessment strategy that aligns assessment with learning. Its success depends on structured faculty training, student orientation, and periodic integration with traditional assessments to achieve a balanced approach that promotes deeper learning and better clinical reasoning preparedness among future medical professionals.

**Author Contributions :** Data collection, data analysis, statistical analysis, and part of the research writing.

**Co-author contribution:** Data interpretation and research writing.

**Conflicts of Interests: None**

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