



ORIGINAL ARTICLE

Evaluation of Post-Assessment Remedial Training for Competency-Based Biochemistry Education for Medical Undergraduates in Haveri district of Karnataka in India

Ashakiran Srinivasaiah,¹ Mahalaxmi S Petimani,² Siddharameshwar M Kantikar³ and Harish Rangareddy^{4,*}

¹*Professor and HOD, Department of Biochemistry, Haveri Institute of Medical Sciences, Haveri-581110*

²*Associate Professor, Department of Biochemistry, Haveri Institute of Medical Sciences, Haveri-581110*

³*Associate Professor, Department of Pathology, Subbaiah Institute of Medical Sciences, Shivamogga, India*

⁴*Assistant Professor, Department of Biochemistry, Haveri Institute of Medical Sciences, Haveri-581110*

Accepted: 16-April-2026 / Published Online: 6-May-2026

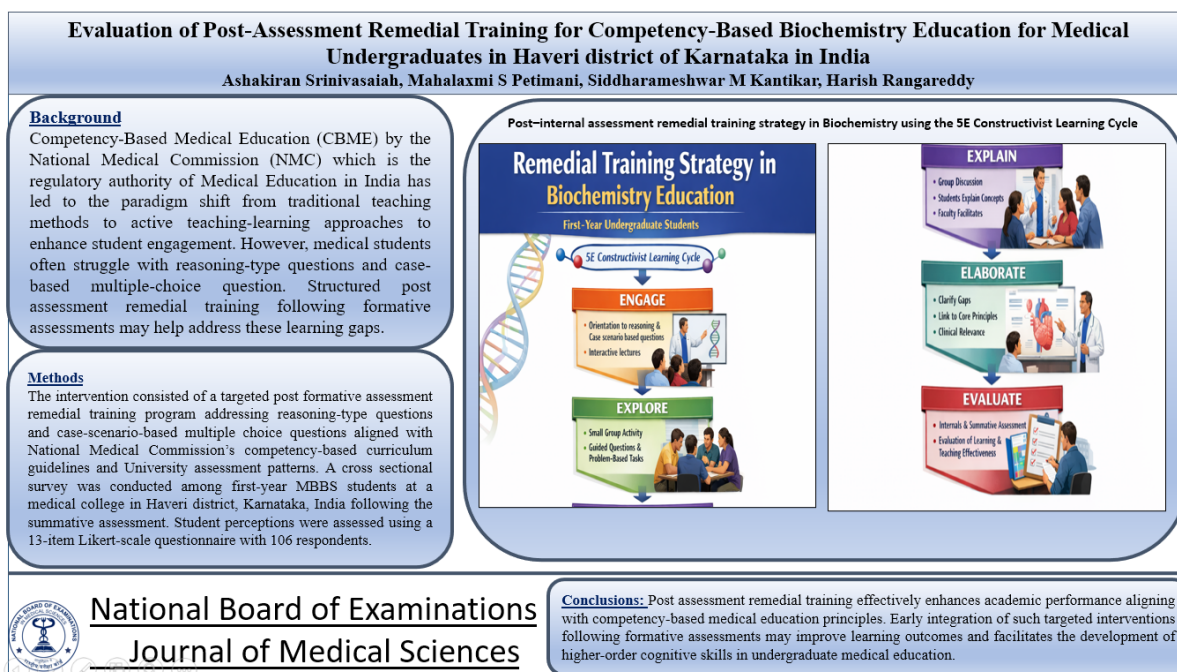
Abstract

Background: Competency-Based Medical Education (CBME) by the National Medical Commission (NMC) which is the regulatory authority of Medical Education in India has led to the paradigm shift from traditional teaching methods to active teaching-learning approaches to enhance student engagement. However, medical students often struggle with reasoning-type questions and case-based multiple-choice question. Structured post assessment remedial training following formative assessments may help address these learning gaps. **Methods:** The intervention consisted of a targeted post formative assessment remedial training program addressing reasoning-type questions and case-scenario-based multiple choice questions aligned with National Medical Commission's competency-based curriculum guidelines and University assessment patterns. A cross sectional survey was conducted among first-year MBBS students at a medical college in Haveri district, Karnataka, India following the summative assessment. Student perceptions were assessed using a 13-item Likert-scale questionnaire with 106 respondents. **Results:** Students reported positive perceptions of the training program with >80% of students agreed or strongly agreed that the sessions improved their understanding of reasoning-type questions, analytical skills, and application of biochemical knowledge to clinical scenarios. Nearly 81% students reported increased confidence in answering case-scenario based questions, and 83% students indicated their willingness to recommend the training to their juniors. No significant differences in perceptions were observed between gender groups or across age categories. The intervention demonstrated a large educational impact (Cohen's $d = 1.58$). **Conclusion:** Post assessment remedial training effectively enhances academic performance aligning with competency-based medical education principles. Early integration of such targeted interventions following formative assessments may improve learning outcomes and facilitates the development of higher-order cognitive skills in undergraduate medical education.

Keywords: Competency-based medical education, Remedial training, Case-scenario based learning, Analytical reasoning

*Corresponding Author: Harish Rangareddy
Email: harishreddy1349@gmail.com

Graphical Abstract



Introduction

Implementation of Competency-Based Medical Education (CBME) by the National Medical Commission (NMC) which is the regulatory authority of Medical Education in India has led to the paradigm shift from traditional teaching methods to active teaching-learning approaches to enhance student engagement [1]. These innovative teaching-learning approaches viz., concept mapping, reflective self-assessment, Multiple Choice Questions (MCQs) when introduced gradually after proper orientation of the students and teachers of Biochemistry in Phase I MBBS Curriculum based on Competencies it has been observed that the students gained confidence in performing better in both the formative assessments as well as summative assessment University examination [2].

The interactive "lecture-tutorial-classroom assessment-feedback" method serves as an ongoing learning tool to identify conceptual gaps, which can be

corrected through feedback, leading to significantly improvement in formative assessment scores and practical understanding in first-year MBBS despite time constraints indicating that feedback plays a crucial role in implementation of CBME [3].

Following the implementation of the revised Graduate Medical Education Regulations (GMER) 2024, NMC has shifted the focus of CBME towards the development of clinical reasoning and application of knowledge [4]. Accordingly, the assessment strategies shall incorporate reasoning-based questions to evaluate students' ability to interpret information, integrate concepts and apply the knowledge in problem-solving contexts. This is outlined in the Annexure 9 of the CBME assessment framework of the revised GMER which mandates the inclusion of reasoning-oriented questions and case-based multiple-choice questions in Biochemistry assessments to promote higher-order

cognitive skills and clinically relevant learning among medical undergraduates [4]. However, it has observed that first-year MBBS students often struggle with these formats of assessment for higher-order thinking [5]. The same Assessment of CBME is adopted by Rajiv Gandhi University of Health Sciences (RGUHS), Bangalore which emphasizes reasoning questions and case-based MCQs in Biochemistry assessments. Post-assessment remedial training addresses this gap [6].

For addressing learning gaps, post-assessment remedial training specifically targeting Biochemistry's reasoning (Q3: 5×3 marks) and case-based MCQs is needed. No prior studies from Haveri Institute of Medical Sciences or similar resource-limited settings have psychometrically validated structured questionnaires to evaluate such remedial interventions' effectiveness, alignment with NMC/RGUHS patterns, perceived learning gains, teaching processes, and satisfaction—essential for institutional adoption and scalability across Indian medical colleges. This study aimed to assess the effectiveness of post assessment remedial training using a structured student feedback questionnaire assessing remedial training on reasoning questions and case scenario based MCQs in Biochemistry for first-year MBBS students and the study was presented at was presented as an Oral paper at the "Virtual International Conference on Health Professions Education" organized on 12th and 13th January, 2026 by University Center for Health Professions Education, Sri Devaraj Urs Academy of Higher Education and Research in Kolar, Karnataka.

Methods

Study Design

This study was conducted among first-year medical undergraduates (MBBS) students at a medical college who had enrolled for the program for the academic year 2024-25 at Haveri Institute of Medical Sciences. A structured remedial training intervention was implemented for first-year undergraduate medical students in Biochemistry who were identified as underperformers based on their performance in the second formative assessment. Students scoring below the predefined competency threshold were enrolled in the remediation programme. The intervention was conducted over a defined period following the second formative assessment and was designed using the 5E constructivist learning cycle (Engage, Explore, Explain, Elaborate, Evaluate) to promote active, learner-centered engagement [7].

During the Engage phase, students were oriented to reasoning- and case scenario-based questions through brief interactive lectures. Subsequently, the students were involved in small group discussions wherein the students articulated their understanding in the Explain phase. Following this the faculty addressed the learning gaps and emphasized the importance of reasoning and clinical relevance while reinforcing the core concepts of Biochemistry in the Elaborate phase. The Evaluate phase included continuous formative assessments integrated with feedback, along with structured assignments, quizzes, mind maps, and quick revision exercises to reinforce learning as depicted in Figure 1.



Figure 1. Flowchart showing the 5E Constructivist Learning Cycle used in the remedial training intervention

Following the completion of the intervention, a post-intervention formative assessment was conducted to evaluate the effectiveness of the remedial strategy. Student performance before and after the intervention was compared to assess improvement in learning outcomes. Additionally, formative feedback was

provided throughout the intervention to support progressive learning and self-improvement. Cross sectional survey was conducted after the summative assessment to assess the effectiveness of the remedial training and also to obtain feedback.

Participants and Sampling

Students were briefed in person about the study's purpose and procedures. All first-year MBBS students were included using universal sampling.

Although a sample size was estimated using the formula for finite population correction:

$$n = \frac{N \cdot Z^2 \cdot p(1 - p)}{(N - 1) \cdot d^2 + Z^2 \cdot p(1 - p)}$$

where N is the population size (11,745), Z is the standard normal deviate corresponding to a 95% confidence level (1.96), p is the expected proportion (0.5), and d is the margin of error (10%), the calculated sample size was approximately 96 using Raosoft® (Sample Size

Calculator; Raosoft inc.) [8]. However, since all eligible students were included, universal sampling was adopted.

Data Collection Tool

A simple structured survey questionnaire was developed by the authors and was used for data collection (Appendix I). To validate the content, the initial version of the questionnaire was reviewed by a panel of subject-matter experts, including faculty members from the Medical Education Unit. Cronbach's alpha was used to assess the internal consistency of the questionnaire which yielded a high reliability co-efficient of 0.963 as shown in Table 1.

Table 1. Internal Consistency Reliability of the Biochemistry Training Feedback Questionnaire

Measure	Value
Number of Questions	13
Cronbach's Alpha	0.963

The study was approved by the institutional ethics committee of Haveri Institute of Medical Sciences. The objectives of the study were explained to the students before administering the questionnaire to ensure informed participation and enhance the validity of the feedback collected. Universal sampling of all first year medical undergraduates was carried out with a response rate of 70.66% (n=106). Google form was used for data collection which was configured to allow only one response per participant to ensure data integrity by preventing multiple submissions. Informed consent was obtained from the students in the Google form itself. Before responding to

the questions, the participants were presented with a consent statement on the first page of the Google form. Only after clicking the consent box to indicate their agreement to participate in the study could they proceed to the next section of the survey. Participation in the survey was voluntary, and the data collected was anonymized, accessible only to the research team.

Data Analysis

Descriptive statistics was employed and Microsoft excel was used to analyze and store the data, with results presented as percentages. Data analysis was performed using Jamovi software for

descriptive and inferential statistical methods. Prior to the inferential analysis, assumptions for parametric testing were evaluated:

- Normality was assessed using the Shapiro–Wilk test
- Homogeneity of variances was assessed using Levene’s test

Since the normality assumption was violated for all questionnaire items ($p < 0.001$), non-parametric statistical tests were used:

- Mann–Whitney U test to compare perception scores between male and female students
- Kruskal–Wallis test to compare perception scores across different age groups

A p -value < 0.05 was considered statistically significant.

Results

This study comprised of 106 first year medical undergraduate from 2024-25 batch whose responses to the self-administered questionnaire provided critical insights into the effectiveness post assessment remedial training in competency based medical education.

Descriptive statistics showed higher mean perception score across the questionnaire items among female students in relative comparison to male students. However, median responses for both gender was consistently “agree” indicating an uniform favourable response for biochemistry training program.

Table 2. Comparison of Students’ Perception of Biochemistry Training Programme Between Male and Female Students (Descriptive Statistics)

Group Descriptive	Group	N	Mean	SD
The reason for organizing this training (poor performance in reasoning and case-based MCQs in the 2nd internal assessment) was clearly explained to us.	Female	50	4.06	0.652
	Male	56	3.95	0.749
The sessions helped me understand the pattern and expectations of the NMC Annexure 9 UG theory paper in Biochemistry.	Female	50	4.16	0.584
	Male	56	4.07	0.783
The training helped me understand how Biochemistry assessment in RGUHS (including reasoning questions and case-based MCQs) has changed in the new curriculum.	Female	50	4.14	0.535
	Male	56	4.04	0.713
The sessions reflected the NMC Annexure 9 pattern and current RGUHS Biochemistry curriculum accurately.	Female	50	4.16	0.468
	Male	56	4.09	0.695
The training improved my understanding of Biochemistry reasoning-type questions (Q3: 5 questions \times 3 marks).	Female	50	4.16	0.548
	Male	56	3.98	0.7

The training in Biochemistry case scenario–based MCQs improved my analytical and problem-solving skills.	Female	50	4.06	0.512
	Male	56	3.96	0.762
The training helped me relate biochemical pathways and core concepts to applied/clinical scenarios.	Female	50	4.18	0.523
	Male	56	3.98	0.726
The difficulty level of the questions practiced during training was similar to what is expected in the summative university examination.	Female	50	4.16	0.548
	Male	56	4	0.739
The teaching methods used (e.g., discussion of answers, explanation of reasoning steps, use of clinical vignettes) were effective for my style of learning.	Female	50	4.12	0.594
	Male	56	4.05	0.84
The training addressed the main difficulties I faced in the 2nd internal assessment Biochemistry paper.	Female	50	4.06	0.586
	Male	56	3.95	0.796
The overall organization of the training (timing, duration, sequence of topics) was appropriate.	Female	50	4.02	0.515
	Male	56	4	0.763
My confidence to attempt reasoning-type questions and case-based MCQs in the university summative examination has increased after this training.	Female	50	4.14	0.572
	Male	56	3.93	0.735
I would recommend this type of training to my juniors for better preparation for internal assessment and university examinations.	Female	50	4.28	0.607
	Male	56	4.02	0.863

The normality of the data collected was assessed using Shapiro-Wilk test and the test yielded significant results ($p <$

0.001) for all items confirming non-normal distributions and necessitating non-parametric analyses as shown in Table 3.

Table 3. Assessment of Normality Assumption Using Shapiro–Wilk Test for Perception by Gender

Normality Test (Shapiro-Wilk Test)	Test Statistic	P-value
The reason for organizing this training (poor performance in reasoning and case-based MCQs in the 2nd internal assessment) was clearly explained to us.	0.867	<0.001
The sessions helped me understand the pattern and expectations of the NMC Annexure 9 UG theory paper in Biochemistry.	0.847	<0.001

The training helped me understand how Biochemistry assessment in RGUHS (including reasoning questions and case-based MCQs) has changed in the new curriculum.	0.831	<0.001
The sessions reflected the NMC Annexure 9 pattern and current RGUHS Biochemistry curriculum accurately.	0.796	<0.001
The training improved my understanding of Biochemistry reasoning-type questions (Q3: 5 questions × 3 marks).	0.863	<0.001
The training in Biochemistry case scenario-based MCQs improved my analytical and problem-solving skills.	0.801	<0.001
The training helped me relate biochemical pathways and core concepts to applied/clinical scenarios.	0.874	<0.001
The difficulty level of the questions practiced during training was similar to what is expected in the summative university examination.	0.86	<0.001
The teaching methods used (e.g., discussion of answers, explanation of reasoning steps, use of clinical vignettes) were effective for my style of learning.	0.822	<0.001
The training addressed the main difficulties I faced in the 2nd internal assessment Biochemistry paper.	0.864	<0.001
The overall organization of the training (timing, duration, sequence of topics) was appropriate.	0.764	<0.001
My confidence to attempt reasoning-type questions and case-based MCQs in the university summative examination has increased after this training.	0.89	<0.001
I would recommend this type of training to my juniors for better preparation for internal assessment and university examinations.	0.9	<0.001

Note: p-value <0.05 indicates violation of the assumption of normality

The variance homogeneity was tested using Levene's test and the p-value was observed to be for $p > 0.05$ for the

majority of items, though select items exhibited heterogeneity ($p < 0.05$) as depicted in Table 4.

Table 4. Homogeneity of Variance Assessment Using Levene's Test Between Male and Female Students

Homogeneity of Variances Test (Levene's Test)	Test Statistic	p-value
The reason for organizing this training (poor performance in reasoning and case-based MCQs in the 2nd internal assessment) was clearly explained to us.	0.921	0.339
The sessions helped me understand the pattern and expectations of the NMC Annexure 9 UG theory paper in Biochemistry.	3.364	0.069

The training helped me understand how Biochemistry assessment in RGUHS (including reasoning questions and case-based MCQs) has changed in the new curriculum.	2.643	0.107
The sessions reflected the NMC Annexure 9 pattern and current RGUHS Biochemistry curriculum accurately.	5.675	0.019
The training improved my understanding of Biochemistry reasoning-type questions (Q3: 5 questions × 3 marks).	1.057	0.306
The training in Biochemistry case scenario-based MCQs improved my analytical and problem-solving skills.	3.432	0.067
The training helped me relate biochemical pathways and core concepts to applied/clinical scenarios.	1.255	0.265
The difficulty level of the questions practiced during training was similar to what is expected in the summative university examination.	2.351	0.128
The teaching methods used (e.g., discussion of answers, explanation of reasoning steps, use of clinical vignettes) were effective for my style of learning.	2.217	0.14
The training addressed the main difficulties I faced in the 2nd internal assessment Biochemistry paper.	4.355	0.039
The overall organization of the training (timing, duration, sequence of topics) was appropriate.	3.399	0.068
My confidence to attempt reasoning-type questions and case-based MCQs in the university summative examination has increased after this training.	1.869	0.175
I would recommend this type of training to my juniors for better preparation for internal assessment and university examinations.	1.505	0.223

Note: p-value <0.05 indicates violation of the assumption of normality

As the data was not normally distributed, non-parametric tests viz., Mann-Whitney U test and Kruskal-Wallis test were employed for subsequent group comparisons. Mann-Whitney U test demonstrated no statistically significant differences in the perceptions regarding training between male and female students

for any of the questionnaire items ($p > 0.05$). This indicates that the students perceived the effectiveness of training, teaching methods, improvement in reasoning skills, alignment with curriculum, and confidence in examination preparation were consistent across gender groups as shown in Table 5.

Table 5. Comparison of Students' Perceptions Regarding Biochemistry Training Programme Between Male and Female Students Using Mann–Whitney U Test

Mann-Whitney U Test	Statistic	p-value
The reason for organizing this training (poor performance in reasoning and case-based MCQs in the 2nd internal assessment) was clearly explained to us.	1293	0.457
The sessions helped me understand the pattern and expectations of the NMC Annexure 9 UG theory paper in Biochemistry.	1338	0.666
The training helped me understand how Biochemistry assessment in RGUHS (including reasoning questions and case-based MCQs) has changed in the new curriculum.	1296	0.454
The sessions reflected the NMC Annexure 9 pattern and current RGUHS Biochemistry curriculum accurately.	1340	0.66
The training improved my understanding of Biochemistry reasoning-type questions (Q3: 5 questions × 3 marks).	1209	0.17
The training in Biochemistry case scenario-based MCQs improved my analytical and problem-solving skills.	1332	0.611
The training helped me relate biochemical pathways and core concepts to applied/clinical scenarios.	1205	0.156
The difficulty level of the questions practiced during training was similar to what is expected in the summative university examination.	1236	0.246
The teaching methods used (e.g., discussion of answers, explanation of reasoning steps, use of clinical vignettes) were effective for my style of learning.	1391	0.952
The training addressed the main difficulties I faced in the 2nd internal assessment Biochemistry paper.	1310	0.527
The overall organization of the training (timing, duration, sequence of topics) was appropriate.	1382	0.893
My confidence to attempt reasoning-type questions and case-based MCQs in the university summative examination has increased after this training.	1187	0.128
I would recommend this type of training to my juniors for better preparation for internal assessment and university examinations.	1192	0.152

The Mann–Whitney U test showed no statistically significant differences between male and female students across all questionnaire items ($p > 0.05$). This indicates that students' perceptions regarding the effectiveness, organization, and impact of the Biochemistry training programme were same across genders.

To assess age group differences in perceptions of the biochemistry training program, normality (Shapiro-Wilk test) and variance homogeneity (Levene's test)

were evaluated. The null hypothesis (H_0 : data normally distributed) versus alternative (H_1 : non-normal) was tested.

The Shapiro-Wilk test indicated significant deviations from normality ($p < 0.001$) across all items, precluding parametric methods as shown in Table 6. Levene's test confirmed variance homogeneity for most items ($p > 0.05$), with isolated exceptions as depicted in Table 7.

Table 6. Assessment of Normality Assumption Using Shapiro–Wilk Test Across Different Age Groups

Normality Test (Shapiro-Wilk)	Test Statistic	p-value
The reason for organizing this training (poor performance in reasoning and case-based MCQs in the 2nd internal assessment) was clearly explained to us.	0.858	<.001
The sessions helped me understand the pattern and expectations of the NMC Annexure 9 UG theory paper in Biochemistry.	0.852	<.001
The training helped me understand how Biochemistry assessment in RGUHS (including reasoning questions and case-based MCQs) has changed in the new curriculum.	0.815	<.001
The sessions reflected the NMC Annexure 9 pattern and current RGUHS Biochemistry curriculum accurately.	0.794	<.001
The training improved my understanding of Biochemistry reasoning-type questions (Q3: 5 questions \times 3 marks).	0.824	<.001
The training in Biochemistry case scenario–based MCQs improved my analytical and problem-solving skills.	0.768	<.001
The training helped me relate biochemical pathways and core concepts to applied/clinical scenarios.	0.804	<.001
The difficulty level of the questions practiced during training was similar to what is expected in the summative university examination.	0.809	<.001
The teaching methods used (e.g., discussion of answers, explanation of reasoning steps, use of clinical vignettes) were effective for my style of learning.	0.837	<.001
The training addressed the main difficulties I faced in the 2nd internal assessment Biochemistry paper.	0.859	<.001
The overall organization of the training (timing, duration, sequence of topics) was appropriate.	0.78	<.001
My confidence to attempt reasoning-type questions and case-based MCQs	0.866	<.001

in the university summative examination has increased after this training.		
I would recommend this type of training to my juniors for better preparation for internal assessment and university examinations.	0.846	<.001

Note: p-value <0.05 indicates violation of the assumption of normality

Table 7. Homogeneity of Variance Assessment across Age Groups Using Levene's Test

Homogeneity of Variances Test (Levene's)	Test Statistic	p-value
The reason for organizing this training (poor performance in reasoning and case-based MCQs in the 2nd internal assessment) was clearly explained to us.	0.3285	0.721
The sessions helped me understand the pattern and expectations of the NMC Annexure 9 UG theory paper in Biochemistry.	0.3364	0.715
The training helped me understand how Biochemistry assessment in RGUHS (including reasoning questions and case-based MCQs) has changed in the new curriculum.	0.0586	0.943
The sessions reflected the NMC Annexure 9 pattern and current RGUHS Biochemistry curriculum accurately.	0.0669	0.935
The training improved my understanding of Biochemistry reasoning-type questions (Q3: 5 questions × 3 marks).	0.0775	0.926
The training in Biochemistry case scenario-based MCQs improved my analytical and problem-solving skills.	0.1747	0.84
The training helped me relate biochemical pathways and core concepts to applied/clinical scenarios.	0.5953	0.553
The difficulty level of the questions practiced during training was similar to what is expected in the summative university examination.	0.3614	0.698
The teaching methods used (e.g., discussion of answers, explanation of reasoning steps, use of clinical vignettes) were effective for my style of learning.	1.7621	0.177
The training addressed the main difficulties I faced in the 2nd internal assessment Biochemistry paper.	1.0683	0.347
The overall organization of the training (timing, duration, sequence of topics) was appropriate.	1.0709	0.346
My confidence to attempt reasoning-type questions and case-based MCQs in the university summative examination has increased after this	1.1066	0.335

training.		
I would recommend this type of training to my juniors for better preparation for internal assessment and university examinations.	1.0938	0.339

Non-parametric Kruskal-Wallis adjusted via Bonferroni correction (Table 8). tests were employed for multi-group comparisons, with post-hoc Dunn's tests

Table 8. Comparison of Students' Perceptions Across Age Groups Using Kruskal–Wallis Test

Kruskal-Wallis	Test statistic	df	p-value
The reason for organizing this training (poor performance in reasoning and case-based MCQs in the 2nd internal assessment) was clearly explained to us.	5.2614	2	0.072
The sessions helped me understand the pattern and expectations of the NMC Annexure 9 UG theory paper in Biochemistry.	0.4141	2	0.813
The training helped me understand how Biochemistry assessment in RGUHS (including reasoning questions and case-based MCQs) has changed in the new curriculum.	0.1919	2	0.908
The sessions reflected the NMC Annexure 9 pattern and current RGUHS Biochemistry curriculum accurately.	0.3059	2	0.858
The training improved my understanding of Biochemistry reasoning-type questions (Q3: 5 questions × 3 marks).	0.31	2	0.856
The training in Biochemistry case scenario-based MCQs improved my analytical and problem-solving skills.	0.1192	2	0.942
The training helped me relate biochemical pathways and core concepts to applied/clinical scenarios.	0.0646	2	0.968
The difficulty level of the questions practiced during training was similar to what is expected in the summative university examination.	0.0617	2	0.97
The teaching methods used (e.g., discussion of answers, explanation of reasoning steps, use of clinical vignettes) were effective for my style of learning.	1.6607	2	0.436
The training addressed the main difficulties I faced in the 2nd internal assessment Biochemistry paper.	0.9504	2	0.622

The overall organization of the training (timing, duration, sequence of topics) was appropriate.	0.8415	2	0.657
My confidence to attempt reasoning-type questions and case-based MCQs in the university summative examination has increased after this training.	1.4715	2	0.479
I would recommend this type of training to my juniors for better preparation for internal assessment and university examinations.	1.2152	2	0.545

The Kruskal–Wallis test showed no statistically significant differences among age groups for any questionnaire item ($p > 0.05$). This indicates consistent perception of the training programme among students across different age categories.

A majority of students reported that the purpose of the training programme was clearly communicated, with 76.8%

indicating agreement or strong agreement regarding clarity of objectives. Most students perceived that the purpose of organizing the training programme was clearly explained. A majority of students either agreed (53.8%) or strongly agreed (23.6%), while only 0.9% disagreed. This indicates effective communication regarding the objectives of the training programme as depicted in Table 9.

Table 9. Distribution of Students' Responses Regarding Clarity about Purpose of Organizing the Biochemistry Training Programme

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	1	0.90%
Neutral	23	21.70%
Agree	57	53.80%
Strongly Agree	25	23.60%
Total	106	100.00%

In understanding the pattern and expectations of the recently introduced changes in the assessment methods in Annexure 9 of GMER by NMC it was observed that more than 80% of students agreed or strongly agreed that the sessions

helped them understand the examination pattern and expectations as depicted in Table 10. However, there was minimal disagreement by the students reflecting the usefulness of the sessions in clarifying assessment requirements and early implementation of the remedial training.

Table 10. Distribution of Students' Responses on Understanding the Pattern and Expectations of NMC Annexure 9 in context to UG Theory Paper

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	1	0.90%
Neutral	17	16.00%
Agree	57	53.80%
Strongly Agree	31	29.20%
Total	106	100.00%

Table 11 shows that a large majority of students reported improved understanding of changes in assessment methods in Biochemistry under the new

curriculum, with 59.4% agreeing and 24.5% strongly agreeing, indicating successful orientation to curriculum reforms by the faculty.

Table 11. Distribution of Students' Responses on Understanding Changes in Biochemistry Assessment under the New Curriculum

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	0	0.00%
Neutral	17	16.00%
Agree	63	59.40%
Strongly Agree	26	24.50%
Total	106	100.00%

The strong alignment between training content and expected examination standards was observed as 88% of students

agreed or strongly agreed that the sessions accurately reflected the curriculum requirements as depicted in Table 12.

Table 12. Distribution of Students' Responses for Alignment of Training Sessions with NMC Annexure 9 and RGUHS Curriculum

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	0	0.00%
Neutral	13	12.30%

Agree	67	63.20%
Strongly Agree	26	24.50%
Total	106	100.00%

The responses further revealed that the training effectively addressed analytical components of the examination

as 83% students perceived improvement in their understanding of reasoning-type questions as depicted in Table 13.

Table 13. Distribution of Students' Responses on Improvement in Understanding of Reasoning-Type Questions

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	0	0.00%
Neutral	18	17.00%
Agree	63	59.40%
Strongly Agree	25	23.60%
Total	106	100.00%

The effectiveness of case scenario-based MCQs using in the remedial training improved their analytical and problem-solving skills as 84% of the students agreed or strongly agreed as depicted in Table 14 indicating that the

curricular reforms by the NMC in incorporating the reasoning type questions and focusing on applied learning methods is very pertinent for the Indian Medical Graduate in being locally competent and globally relevant.

Table 14. Distribution of Students' Responses on Improvement in Analytical and Problem-Solving Skills through Case-Based MCQs

Opinion	Counts	% of Total
Strongly Disagree	1	0.90%
Disagree	0	0.00%
Neutral	16	15.10%
Agree	69	65.10%

Strongly Agree	20	18.90%
Total	106	100.00%

The successful integration of theoretical knowledge with clinical application was observed with more than

84% of students agreeing or strongly agreeing that the training helped them relate biochemical pathways to clinical scenarios as depicted in Table 15.

Table 15. Distribution of Students' Responses on their Ability to Relate Biochemical Concepts to Clinical Scenarios

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	1	0.90%
Neutral	15	14.20%
Agree	65	61.30%
Strongly Agree	25	23.60%
Total	106	100.00%

A majority of students perceived that the difficulty level of practice questions matched university examination expectations, with over 82% agreement or strong agreement as shown in Table 16.

This further supports the guidelines set forth by NMC that the final formative assessment shall be along the lines of the summative assessment.

Table 16. Distribution of Students' Responses on Similarity of Training Question Difficulty Level to University Examination

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	0	0.00%
Neutral	19	17.90%
Agree	60	56.60%
Strongly Agree	27	25.50%
Total	106	100.00%

Approximately 84% of students reported that teaching methods such as answer discussions and clinical vignettes

were effective for their learning style. Very low disagreement indicates overall satisfaction with teaching strategies as shown in Table 17.

Table 17. Distribution of Students' Responses on Effectiveness of Teaching Methods Used During Training

Opinion	Counts	% of Total
Strongly Disagree	1	0.90%
Disagree	1	0.90%
Neutral	15	14.20%
Agree	60	56.60%
Strongly Agree	29	27.40%
Total	106	100.00%

Nearly 79% of students agreed or strongly agreed that the training addressed their difficulties from the second internal

assessment. Minimal disagreement suggests that the intervention effectively targeted learning gaps as depicted in Table 18.

Table 18. Distribution of Students' Responses on Addressing Difficulties Faced in Second Internal Assessment

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	2	1.90%
Neutral	20	18.90%
Agree	60	56.60%
Strongly Agree	24	22.60%
Total	106	100.00%

Most students perceived the organization of the training programme as appropriate, with more than 84% expressing agreement

or strong agreement. This indicates satisfaction with timing, duration, and sequencing of sessions as shown in Table 19.

Table 19. Distribution of Students' Responses on Organization and Structure of the Training Programme

Opinion	Counts	% of Total
Strongly Disagree	1	0.90%
Disagree	0	0.00%
Neutral	16	15.10%
Agree	69	65.10%
Strongly Agree	20	18.90%
Total	106	100.00%

A large proportion of students reported increased confidence in attempting reasoning-type and case-based

MCQs, with more than 81% agreement or strong agreement. This reflects the positive impact of the training on examination preparedness as Table 20.

Table 20. Distribution of Students' Responses on Improvement in Confidence to Attempt Reasoning and Case-Based Questions

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	1	0.90%
Neutral	19	17.90%
Agree	62	58.50%
Strongly Agree	24	22.60%
Total	106	100.00%

More than 83% of students indicated willingness to recommend the training programme to their juniors,

demonstrating overall satisfaction and perceived usefulness of the intervention as depicted in Table 21.

Table 21. Distribution of Students' Responses on Recommendation of Training Programme to Juniors

Opinion	Counts	% of Total
Strongly Disagree	0	0.00%
Disagree	3	2.80%
Neutral	15	14.20%
Agree	52	49.10%
Strongly Agree	36	34.00%
Total	106	100.00%

The mean assessment score of the students increased by 18.74 percentage points following the structured post-assessment remedial training demonstrating a substantial improvement

in academic performance as indicated by a highly significant difference between pre- and post-intervention scores as shown in Table 22.

Table 22. Comparison of Pre- and Post-Intervention Assessment Scores

Assessment	Mean (%)	SD	Mean Difference	t value	p value	Effect Size (Cohen's d)
Pre-intervention Internal Assessment	35.99	12.49	18.74	-19.25	<0.001	1.58 (Large)
Post-intervention Internal Assessment	54.72	13.18				

Discussion

The results of this study show that structured post assessment remedial training facilitates first-year medical students studying biochemistry to perform much better academically. The intervention had a considerable educational impact as evident from the large effect size, supporting the principles of competency-based medical education, which emphasize continuous formative

assessment & targeted remediation facilitate mastery of higher-order thinking while the reasoning-type questions and case-scenario-based MCQs can effectively bridge learning gaps in foundational biomedical sciences.

There has been a major paradigm shift with competency based medical education towards an outcomes based learner progression which prioritizes demonstrable competencies and certifiable

skills as against the time based training of the traditional curriculum [9]. In his commentary, Harden RM has highlighted that competency-based frameworks require educational strategies that actively support learners who struggle to achieve expected competencies through timely feedback and targeted interventions [10]. Frank JR et al, in their comprehensive systematic review have found that outcomes based education represents a shift away from time-based progression toward competency attainment, and there is an emphasis on demonstrable abilities assessed through structured evaluation methods [11]. CBME is characterized by its learner-centered approach and alignment with societal and healthcare needs, ensuring that training is relevant to real-world clinical practice [11].

This study findings concur with previous research by Panchbude S et al, demonstrating the effectiveness of structured formative assessment strategies in improving learning outcomes in Biochemistry [12]. Panchbudhe S et al, used Google Form-based MCQ assessments, which was shown to significantly enhance student performance and engagement by providing immediate feedback and reinforcing conceptual understanding [12]. Similar to these findings, the remedial training intervention in our study utilized the Elaborate phase of the learner driven strategy to identify learning gaps and faculty provided feedback to facilitate targeted improvement. The substantial gain in academic performance observed in both studies highlights the importance of integrating regular formative assessments with feedback mechanisms to promote active learning and competency development.

Padwal M et al, compared facilitated learning and self-paced self-directed learning (SDL) and found that though both approaches significantly improved student performance, facilitated learning tends to yield superior outcomes due to guided interaction, feedback and clarification of concepts [13]. Similarly, our study also emphasizes the importance of learner engagement and structured guidance in achieving better learning outcomes [13].

Hauer et al, described remedial training as an essential component of medical education designed to support struggling learners and prevent long-term academic failure in his thematic analysis and also further suggested that effective remediation requires a structured approach incorporating multiple assessment methods, individualized instructions with opportunities for deliberate practice with feedback and reflection [14]. Our study aligns with this based on targeted identification of learning gaps and structured post assessment remedial training. Cleland J et al, found that there was a significant variability in the design and implementation of remediation programs with limited clarity regarding the specific components responsible for improved outcomes [15]. This necessitates a need for multi-institutional, outcomes-based research to establish standardized and evidence-based remediation strategies.

Pawade et al, have identified “blueprinting” as a systematic approach to align assessments with defined competencies, ensuring that the assessment methods comprehensively reflect both curricular content and expected learning outcomes. By mapping syllabus components to the competencies and assigning appropriate weightage across

recall, reason and apply questions facilitate balanced assessment of knowledge, application, and higher-order thinking skills [16]. Our study similarly highlights the importance of assessment driven learning. Furthermore, the National Medical Commission continues to emphasize outcome-based and learner-centred assessment strategies to strengthen competency development in undergraduate medical education through the recent GMER [4].

In addition to improving the academic performance of students in formative assessment, the effectiveness of the structured post assessment remedial training was observed in the university summative examination as reflected by the students' performance with 98.66% of students successfully passing Biochemistry and a substantial number achieving distinctions. This indicates that structured post-assessment training not only improves students' performance in formative assessment but also helps reinforce key concepts and enhance students' preparedness for summative assessment.

Strengths of the Study

This study addresses an important yet underexplored area in competency-based medical education, firstly the role of structured remedial training interventions following formative assessments in Biochemistry. A validated questionnaire with excellent internal consistency was used ensuring reliability in measuring students' perceptions of the intervention. The analysis employed appropriate statistical methods after evaluating assumptions of normality and subsequently non-parametric tests were employed to test the significance, thereby

strengthening the methodological rigor of the findings.

Limitations

Despite its strengths, this study has certain limitations. The study relied primarily on self-reported student perceptions, which may not directly reflect objective improvements in academic performance. However, to circumvent this paired t test was performed to objectively assess the improvements in academic performance. The study was conducted at a single medical institution, which may limit the generalizability of the findings and hence future prospective multi center studies are needed to further evaluate the effectiveness of such interventions. Further a control group was not used to establish causal inference and this may introduce potential bias in attributing improvements solely to the intervention. However, this may be considered for future multi center studies.

Conclusion

This study depicts the critical importance of early identification and structured remediation for underperforming first-year medical students in Biochemistry. The study further demonstrates that structured post assessment remedial training substantially enhances both formative and summative assessment outcomes with constructivist principles as a sustainable approach to improving academic performance and fostering learner confidence in medical education. Students also reported improved conceptual understanding, improved exam preparedness, enhanced time management, and more positive attitudes toward the subject. Overall, these findings align. The study strongly supports

the principles of competency-based medical education, which emphasize continuous formative assessment & targeted remediation facilitate mastery of higher-order thinking while the reasoning-type questions and case-scenario-based MCQs can effectively bridge learning gaps in foundational subject like Biochemistry.

Acknowledgements

The authors would like to express their gratitude to Dr. Sagar Matur, Assistant Professor (Statistics) of Community Medicine, Haveri Institute of Medical Sciences for his support in the statistical analysis. The authors would also like to acknowledge the cooperation of the MBBS students of 2024-25 of Haveri Institute of Medical Sciences who actively took part in this study. Their feedback shall be instrumental in the successful implementation of the remedial training program for the next batches.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

Funding

This research received no external funding from any public, commercial, or not-for-profit funding agencies.

Ethical Considerations

The study was conducted in accordance with ethical principles governing biomedical and educational research involving human participants. Ethical approval for the study was obtained from the Institutional Ethics Committee, Haveri Institute of Medical Sciences, Haveri. Participation in the study was voluntary, and informed consent was

obtained from the participating students. All responses were anonymized to ensure confidentiality and privacy.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Data are not publicly available due to institutional policies regarding student academic records and confidentiality.

References

1. Rangareddy H, Govinda Swamy KS, S A, Petimani MS. Enhancing Student Engagement Through Active Teaching-Learning Approaches Among First-Year Medical Undergraduates. *Cureus*. 2025 Jun 13;17(6):e85921. doi: 10.7759/cureus.85921.
2. Santra R, Saha S, Barua N, et al. Introducing various formative assessment methods in Biochemistry of Phase I MBBS Curriculum. *National Journal of Physiology, Pharmacy and Pharmacology*. 2025 May 1;15(4):267-271.
3. Hemal Panchal, Minal Patel, Sarmishtha Ghosh et al. From Passive Reception to Active Engagement: Transforming learning for first-year medical students under the Competency based medical curriculum, 02 June 2025, PREPRINT (Version 1) available at Research Square <https://doi.org/10.21203/rs.3.rs-6427549/v1>
4. National Medical Commission. Competency-Based Medical Education (CBME) Curriculum Guidelines 2024. New Delhi:

- National Medical Commission; 2024. Available from: <https://www.nmc.org.in/wp-content/uploads/2026/02/12bCompetencyBasedMedicalEducationCBMECurriculum12092024.pdf>
5. Sadath A, Unnikrishnan B, Sharma A, et al. Perception of MBBS Students in Mangalore Regarding Assessment Patterns in Competency-Based Medical Education Curriculum: A Cross-Sectional Study. *Indian Journal of Community Medicine*. 2025 Nov 1;50(6):1064-8.
 6. Japa PK, Fathima M, Samudrala S, et al. Competency-based Medical Education of Biochemistry: The Students' Feedback. *Indian Journal of Medical Biochemistry*. 2025 May 20;29(2):141-6.
 7. Burrowes, PA. A Student-Centered Approach to Teaching General Biology That Really Works: Lord's Constructivist Model Put to a Test. *The American Biology Teacher*. 2003; 65(7): 491-502.
 8. Raosoft I. Sample Size Calculator by Raosoft Inc. [Online] [(accessed on 16 September 2025)]. Available online: <http://www.raosoft.com/samplesize.html>
 9. Frank JR, Snell LS, Cate OT, et al. Competency-based medical education: theory to practice. *Med Teach*. 2010;32(8):638-45. doi: 10.3109/0142159X.2010.501190.
 10. Harden RM. Outcome-Based Education: the future is today. *Med Teach*. 2007 Sep;29(7):625-9. doi: 10.1080/01421590701729930.
 11. Frank JR, Mungroo R, Ahmad Y, et al. Toward a definition of competency-based education in medicine: a systematic review of published definitions. *Med Teach*. 2010;32(8):631-7. doi: 10.3109/0142159X.2010.500898.
 12. Panchbudhe S, Shaikh S, Swami H, Kadam CY, Padalkar R, Shivkar RR, Gulavani G, Gulajkar S, Gawade S, Mujawar F. Efficacy of Google Form-based MCQ tests for formative assessment in medical biochemistry education. *J Educ Health Promot*. 2024 Mar 28;13:92. doi: 10.4103/jehp.jehp_981_23.
 13. Padwal M, Takale L, Phadke A, et al. Self-Directed Learning Strategies: A Comparative Evaluation of Facilitated and Self-Paced Methods. *Cureus*. 2025 Jul 29;17(7):e88982. doi: 10.7759/cureus.88982.
 14. Hauer KE, Ciccone A, Henzel TR, et al. Remediation of the deficiencies of physicians across the continuum from medical school to practice: a thematic review of the literature. *Acad Med*. 2009 Dec;84(12):1822-32. doi: 10.1097/ACM.0b013e3181bf3170.
 15. Cleland J, Leggett H, Sandars J, et al. The remediation challenge: theoretical and methodological insights from a systematic review. *Med Educ*. 2013 Mar;47(3):242-51. doi: 10.1111/medu.12052.
 16. Pawade YR, Chalak AS. Unlock the Secret to Effective Biochemistry Assessment: A Blueprinting Approach for CBME Mastery in India. *Indian Journal of Medical Biochemistry*. 2025 May;29(2):81.

Appendix 1. Study Questionnaire

Section	Question	Options
Section 1: Demographics	What is your age?	17-19 years, 20-22 years, 23-25 years, 26 years and above
	What is your gender?	Male, Female, Prefer not to say
Section 2: Assessment alignment	The reason for organizing this training (poor performance in reasoning and case-based MCQs in the 2nd internal assessment) was clearly explained to us.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
	The sessions helped me understand the pattern and expectations of the NMC Annexure 9 UG theory paper in Biochemistry.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
Section 3: Perceived learning gain	The training helped me understand how Biochemistry assessment in RGUHS (including reasoning questions and case-based MCQs) has changed in the new curriculum.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
	The sessions reflected the NMC Annexure 9 pattern and current RGUHS Biochemistry curriculum accurately.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
	The training improved my understanding of Biochemistry reasoning type questions (Q3: 5 questions × 3 marks).	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
	The training in Biochemistry case scenario-based MCQs improved my analytical and problem-solving skills.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
	The training helped me relate biochemical pathways and core concepts to applied/clinical scenarios.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
Section 4: Teaching process and	The difficulty level of the questions practiced during training was similar to what is expected in the summative university examination.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree

resources	The teaching methods used (e.g., discussion of answers, explanation of reasoning steps, use of clinical vignettes) were effective for my style of learning.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
	The training addressed the main difficulties I faced in the 2nd internal assessment Biochemistry paper.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
	The overall organization of the training (timing, duration, sequence of topics) was appropriate.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
Section 5: Satisfaction and future preference for such training	My confidence to attempt reasoning-type questions and case-based MCQs in the university summative examination has increased after this training.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree
	I would recommend this type of training to my juniors for better preparation for internal assessment and university examinations.	Strongly agree, Agree, Neutral, Disagree, Strongly disagree