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Efficacy of Google Form–based MCQ tests for formative assessment in medical biochemistry education

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Abstract:

BACKGROUND: Biochemistry, being a vast and complex subject, can be challenging for Phase I MBBS students to comprehend and retain. Embracing rapidly evolving technology can facilitate a more accessible learning experience. In this study, we investigated the effectiveness of using Google Form–based multiple-choice question (MCQ) tests as a formative assessment tool after each biochemistry lecture series. The aim was to assess the improvement and gather feedback of Phase I MBBS students on the utility of this assessment tool.

MATERIALS AND METHODS: This educational prospective longitudinal study was conducted by the Department of Biochemistry at a university-affiliated medical college and tertiary care hospital. The study included 150 Phase I MBBS students as participants. Google Form–based MCQ tests were implemented as educational interventions after each lecture series during the study period. The study compared the internal assessment (IA) MCQ marks of students before and after the implementation of the intervention. In addition, feedback questionnaires were collected from the students.

RESULTS: There was a significant improvement in students' scores between the first IA (mean \pm standard deviation [SD], 8.16 ± 3.08) and second IA (mean \pm SD, 17.64 ± 2.02) ($P < 0.0001$). According to students' feedback, 149 out of 150 (99.3%) students found the use of Google Form–based MCQ tests as a formative assessment tool in the teaching–learning process to be highly beneficial and motivated them to engage in their biochemistry studies.

CONCLUSION: With the shift toward competency-based medical education (CBME) in India, it is crucial for educators to embrace novel teaching–learning and evaluation approaches. Our study highlighted the efficacy of employing Google Form–based MCQ tests in enhancing students' comprehension of the biochemistry subject, evaluating their scores and improving the overall quality of learning. Through this mode of assessment, teachers were able to provide targeted feedback on areas that required improvement, thereby enhancing the learning experience.

Keywords:

Biochemistry, CBME, formative assessment, Google Forms, MCQ test

Introduction

Throughout history, the field of medicine and health-care systems has witnessed a multitude of discoveries and innovations. Similarly, the process of medical education has undergone significant transformations since ancient times. Initially, medical

knowledge was acquired through a combination of curiosity-driven enquiry, observation of experienced physicians, and engaging in discussions about diseases and their treatments. The student–teacher relationship played a crucial role in this context, as aspiring physicians would learn by apprenticing to a seasoned practitioner over an extended period. As time progressed,

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the establishment of medical schools introduced a more systematic approach to medical education. These institutions developed structured curricula to guide the learning process. In addition, books on medicine were written providing comprehensive resources for students to study. Furthermore, examinations and assessments were implemented to evaluate and support the educational journey. These developments aimed to enhance the effectiveness and standardization of medical education.^[1] In the past, medical education primarily relied on a one-way teaching approach, often centered around didactic lectures. While this method was essential, it limited student participation to a great extent.^[2] However, as technology advanced, there was a deliberate effort to enhance traditional classroom teaching by incorporating technology and simulations, aiming to foster better understanding and student engagement, particularly during the coronavirus disease 2019 (COVID-19) pandemic.^[3-5] Although the increased use of technology posed challenges such as reliability, feasibility, and the need for prior exposure to online teaching and learning, it was recognized as an effective tool due to its numerous benefits.^[6-8]

In Indian medical education, there has been recent adoption of the competency-based medical education (CBME) model, aiming to enhance the quality of education and produce clinically competent doctors. This transition necessitates a significant shift not only in teaching methods, but also in the approach to periodic assessments. The primary objective is to enable teachers to assess learners' progress and determine if additional or alternative learning opportunities are required to attain competency.^[9] Consequently, apart from traditional didactic lectures and summative assessments, the inclusion of regular formative assessments, primarily centered around providing feedback, is deemed essential.^[10,11] The field of medical education now incorporates a range of teaching–learning methods, including problem-based learning (PBL), self-directed learning (SDL), small group discussions (SGD), Attitude, Ethics and Communication (AETCOM) sessions, and more.^[12] To enhance their teaching techniques with the aid of modern technology, educators in medical education are encouraged to participate in medical education training (MET) workshops and faculty development programs (FDPs). These initiatives aim to expand the repertoire of teaching–learning tools available.^[13]

Biochemistry is intrinsically intertwined with life itself, as it delves into the molecular and chemical aspects that underpin the functioning and structure of living organisms. It plays a vital role in evidence-based clinical practice and forms the foundation of diagnostic, screening, and prognostic biochemical laboratory testing.^[14] Despite

its paramount importance, Phase I MBBS students often encounter challenges in comprehending and retaining the vastness and intricate details of the subject. However, with the rapid advancements in technology, it is possible to facilitate a better understanding of biochemistry. Utilizing the power of evolving technology, multiple-choice questions (MCQs) administered through platforms like Google Forms can serve as a valuable tool for quick formative assessments in biochemistry.^[15]

In line with this, the present study was conducted with the objective of exploring the effectiveness of MCQ tests based on Google Forms after each lecture series in biochemistry for Phase I MBBS students at a university-affiliated medical college and tertiary care hospital. The study aimed to track the students' progress and gather their feedback on this assessment approach. The findings of this study can shed light on the importance of incorporating periodic formative assessments, which are crucial for implementing the new CBME curriculum effectively. In addition, this study has the potential to enhance student–teacher interaction and improve the feedback system, ultimately enriching students' knowledge and interest in biochemistry by utilizing technology as a tool for effective teaching and learning.

Materials and Methods

Study design and setting: An educational prospective longitudinal study was conducted in the Department of Biochemistry at a university-affiliated medical college and tertiary care hospital.

Study participants and sampling: The study included 150 phase I MBBS students over a period of 6 months. Biochemistry subject was taught over two terms. The internal assessment (IA) exams were conducted at the end of each term. To assess the effectiveness of Google Form–based MCQ tests, regular tests were conducted after every lecture series in the second term. At the end of each lecture, students were provided with Google Form link on their mobile phones or tablets. They were asked to answer clinically oriented, concept-based and case scenario–based MCQs related to the topic taught during the lecture. Students were given approximately 45 s to solve each question. The number of MCQs varied from 10 to 20. MCQs were designed to encompass all levels of knowledge domain (Bloom's taxonomy of cognitive domain),^[16] aiming to stimulate critical thinking and higher-order cognitive skills among the students. The question framing followed the pattern set by the university for IA examinations, ensuring a similar level of difficulty in both the IA examinations. After the completion of the test, scores and correct answers were released to the students via their registered email

IDs. If any of the students were absent, they could still solve the MCQs through the link after reading the topic themselves. A record of all the MCQ tests of each student was maintained throughout the study. The educators' opinions were discussed in the departmental meetings. Students were given focused feedback wherever necessary. Difficult-to-understand topics were identified and such topics were taught again. Remedial teaching and SGD were conducted to reinforce understanding. To evaluate the impact of Google Form-based MCQ tests, the MCQ marks obtained by students in the first and second term IAs in biochemistry were recorded and compared.

Ethical consideration: The study was approved by the Institutional Ethical Committee, and voluntary consent was obtained from the study participants.

Data collection tool and technique: A Google Form- feedback questionnaire comprising 10 questions was obtained anonymously from the students to eliminate any bias and to gather their experience through the study. The feedback was collected to gain insights into the students' perspectives on the study, assess if they perceived any benefits from it, and determine if there were any areas that required further improvements. The feedback questionnaire is shown in Table 1.

Statistical analysis

Statistical analysis and calculations for both the IA MCQs marks and the feedback data were conducted using various tools and software, including Google Forms, Google Spreadsheet, GraphPad Prism 9, and formulas in Microsoft Excel. The results were calculated and presented as mean \pm standard deviation. Paired *t*-test was used to compare the first and second term IA MCQ marks of the participants before and after the educational intervention, respectively. Percentage analysis, aimed to assess the impact of the educational intervention on the distribution

of students, was done to evaluate the percentage of students falling into four distinct categories based on their MCQ marks. Percentage analysis was done additionally to evaluate the responses of participants to feedback questionnaire, which was aimed to gather feedback to gain insights into the students' perspectives on this study. Pearson correlation analysis was performed to examine the relationship between the improved performance of students after the educational intervention provided through the Google Form-based MCQ tests and the before intervention marks. *P*-value <0.05 was considered statistically significant.

Results

A total of 150 phase I MBBS students participated in the study. The IA exams consisted of 20 MCQs, with each MCQ worth one mark (total marks = 20). The passing marks were set at 10 out of 20 (50%). The mean score for the first term IA MCQ marks was 8.16 ± 3.08 , while for the second term, it was 17.64 ± 2.02 . A statistically significant difference ($P < 0.0001$) was found in the performance of students in the second term IA compared to the first term IA. This suggests that the utilization of Google Form-based MCQ tests was effective in improving the overall performance and response of the students. In addition, percentage analysis revealed that in the first term IA MCQ test, the majority of students, 92 students (61.3%), scored between 6 and 10 marks, followed by 31 students (20.6%) scoring between 11 and 15 marks. Twenty-five students (16.6%) scored ≤ 5 marks, and only two students (1.33%) scored ≥ 16 marks out of 20. In contrast, after the introduction of regular formative assessments and effective student-teacher feedback sessions in the second term, overall improved performances were observed. In the second term IA MCQ test, the majority of students, 124 students (82.6%), scored ≥ 16 marks. Twenty-five students (16.6%) scored between 11 and 15 marks, and only one student (0.66%)

Table 1: Feedback questionnaire regarding the MCQ tests via Google Form

Serial Number	Feedback question	Response
1	Do you like this type of teaching-learning method?	Yes/No
2	Did it help you to understand Biochemistry subject better?	Yes/No
3	Do you look forward to online MCQ test at the end of each topic?	Yes/No
4	Was the time provided to solve the MCQ test sufficient?	Yes/No
5	Did it help you to identify your learning needs and areas of improvement related to Biochemistry?	Yes/No
6	Do you think that this type of MCQ assessment at the end of lecture encourages you to be more attentive during the lecture?	SA*/A**/DA***
7	Do you think this form of formative assessment allows you to apply knowledge gained during the Biochemistry lectures, clinically?	SA*/A**/DA***
8	Do you think such assessments are useful in preparing for competitive exams like NEET-PG, NEXT, USMLE, etc.?	SA*/A**/DA***
9	Were you motivated to study and did your performance in Internal Assessment exams improve after the introduction of online MCQ tests?	Yes/No
10	Do you think this form of MCQ test based on Google Forms should be included regularly?	Yes/No

*SA - Strongly agree; **A - Agree; ***DA - Disagree

scored between 6 and 10 marks. No student scored ≤ 5 marks in the second term exam. Table 2 and Graph 1 summarize the collected data. In the first term, out of the total 150 students, only 41 students (27.33%) were able to score above the passing marks, ≥ 10 out of 20. However, in the second term, all 150 students (100%) successfully passed the exam by achieving a score above the passing marks threshold [Graph 2]. Furthermore, analysis of Pearson correlation coefficient revealed a significant negative correlation ($r = -0.77, P < 0.0001$) between the improved performance of students after the educational intervention provided through the Google Form-based MCQ tests and the before intervention marks. This negative correlation indicates that the intervention had a more pronounced effect on students with lower initial performance. It suggests that the educational intervention was particularly effective in helping students improve their scores if they had lower marks before the intervention and emphasizes its effectiveness in achieving the desired outcomes.

To gather feedback from the participants regarding the MCQ tests during lectures, an anonymous Google Form-feedback questionnaire was administered and their responses were analyzed. The results showed that all 150 students (100%) liked this teaching-learning method. A majority of the participants, 147 students (98%), believed that the formative assessments followed by feedback helped them understand the subject better. Similarly, 148 students (98.7%) expressed their anticipation for MCQ tests after every lecture series,

and 142 participants (94.7%) found the allotted time for solving the tests sufficient. In terms of the study impact, 149 students (99.3%) acknowledged that it helped them identify their learning needs and areas for improvement in biochemistry. Moreover, a significant number of participants, 108 students (72%), strongly agreed that the study increased their attentiveness during lectures, knowing that a test awaited them at the end. In addition, a majority of students, with 94 students (62.7%) strongly agreeing, 53 students (35.3%) agreeing, and only three students (2%) disagreeing, found the formative assessments beneficial for applying the gained knowledge clinically. Participants were also asked about the usefulness of such assessments in preparing for competitive exams like NEET-PG, NEXT, USMLE, PLAB, etc., In response, 110 students (73.3%) strongly agreed with their usefulness. Furthermore, almost all participants (99.3%) reported that they were motivated to study and witnessed an improvement in their performance in IA exams after the introduction of online MCQ tests. Finally, when asked if the Google Form-based MCQ tests should be regularly included, 148 students (98.7%) responded positively. The summarized responses of the participants in percentage values are presented in Table 3.

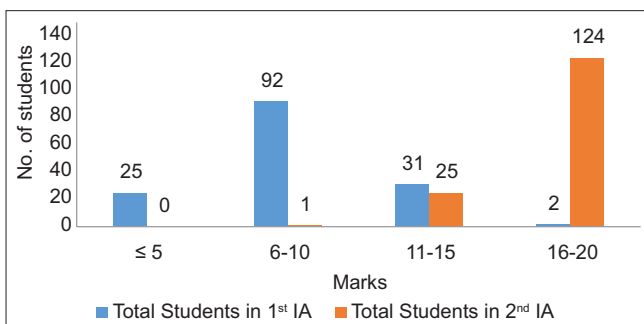
Discussion

It is a rather well-known fact that “assessment drives learning.” Regular strategic assessments of students during their educational course not only motivates them to study, but also makes them realize their shortcomings.^[17,18] In the present study, we examined the acceptability and effectiveness of regular formative assessments in the form of MCQ tests using Google Forms when biochemistry was studied by the students. The results of our study indicated an overall positive response from the students toward the implementation of regular formative assessments.

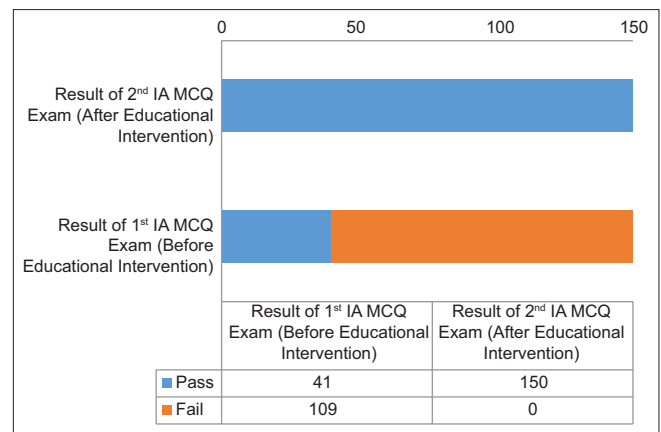
Table 2: Distribution and percentage (%) of students into distinct categories based on MCQ marks in the first and second IA

Marks	Distribution and percentage of students – first IA	Distribution and percentage of students – second IA
≤ 5	25 (16.6%)	0
6–10	92 (61.3%)	1 (0.66%)
11–15	31 (20.6%)	25 (16.6%)
16–20	2 (1.33%)	124 (82.6%)

The values given in bold indicates shift in score showing improvement in performance of the students after educational intervention



Graph 1: Comparison of first and second term IA MCQ marks. IA = internal assessment, MCQ = multiple-choice questions



Graph 2: Comparative analysis of the participants' MCQ exam result in the first IA (before the educational intervention) and second IA (after the educational intervention). IA = internal assessment, MCQ = multiple-choice questions

Table 3: Summary of Google Form–based feedback questionnaire showing responses of participants in percentage (%) values

Q. No.	Question	Response (%)	Response (%)	Response (%)
1	Do you like this type of teaching–learning method?	Yes (100%)	No (0%)	-
2	Did it help you to understand biochemistry subject better?	Yes (98%)	No (2%)	-
3	Do you look forward to online MCQ test at the end of each topic?	Yes (98.7%)	No (1.3%)	-
4	Was the time provided to solve the MCQ test sufficient?	Yes (94.7%)	No (5.3%)	-
5	Did it help you to identify your learning needs and areas of improvement related to biochemistry?	Yes (99.3%)	No (0.7%)	-
6	Do you think that this type of MCQ assessment at the end of lecture encourages you to be more attentive during the lecture?	SA ^a (72%)	A ^b (28%)	DA ^c (0%)
7	Do you think this form of formative assessment allows you to apply knowledge gained during the biochemistry lectures, clinically?	SA ^a (62.7%)	A ^b (35.3%)	DA ^c (2%)
8	Do you think such assessments are useful in preparing for competitive exams like NEET-PG, NEXT, USMLE, etc.?	SA ^a (73.3%)	A ^b (26%)	DA ^c (0%)
9	Were you motivated to study and did your performance in internal assessment exams improve after the introduction of online MCQ tests?	Yes (99.3%)	No (0.7%)	-
10	Do you think this form of MCQ test based on Google Forms should be included regularly?	Yes (98.7%)	No (1.3%)	-

^aSA=strongly agree, ^bA=agree, ^cDA=disagree

The feedback received from the majority of students indicated a positive perception toward the MCQ tests based on Google Forms and expressed anticipation for these assessments at the end of each lecture. They highlighted the benefits of being able to apply the knowledge gained during biochemistry lectures in a clinical context. In addition, the students found that the MCQ format facilitated their ability to memorize the subject and its complex details. They appreciated how MCQs helped them summarize the lectures and revise the content in a concise and effective manner.

A high percentage (98.7%) of participants in our study expressed the opinion that the inclusion of MCQ tests regularly in the curriculum as formative assessments would be beneficial. These findings align with a large-scale Indian study involving 7875 medical students, where 85% of the students expressed the opinion that MCQ-oriented preparation was useful for MBBS examinations and should be initiated from the first year of the program.^[19] However, it is worth noting that a study conducted at Zucker School of Medicine reported a different perspective, with 54% of students and faculty preferring a context-rich short answer question (CR-SAQ) exam format over MCQs during the pre-clinical years. Their preference stemmed from the belief that CR-SAQs require better recall of the topic and help prevent the cueing effect.^[20] These varying opinions highlight the importance of considering contextual factors and individual preferences when designing assessment methods in medical education.

In our study, the majority of students expressed that the allocated time for solving the exams was sufficient. This finding is consistent with a survey conducted to gather medical students' perceptions of e-assessment, where 71% of the participants agreed that online exams with

MCQs provided ample time for students to answer and complete the examination.^[21] The alignment of these results suggests that the students' perception of adequate time for MCQ-based exams is a common observation across different studies, highlighting the practicality and feasibility of such assessment formats in the context of medical education.

The educators who participated in the study expressed their belief that customizing MCQs to align with students' needs and educational objectives promoted deeper learning. Traditionally, assessments primarily focus on factual knowledge acquisition. However, the utilization of MCQs enables the assessment of comprehension, content integration, and recall testing. Moreover, MCQs allow for broader coverage of content compared to other assessment methods. These findings are consistent with an Indian study that emphasized the significance of FDPs in enhancing the quality of MCQ construction, ultimately contributing to improved MCQs.^[22] The inclusion of tailored MCQs and the provision of appropriate training for educators can contribute to the effective use of this assessment format in promoting comprehensive learning outcomes. Google Forms serves as a self-grading and self-evaluating platform, offering easy navigation and providing instant feedback to students while generating automated scores for teachers. This feature eliminates the need for manual review of students' answers, thereby reducing workload. In addition, by replacing traditional pen-and-paper exams, Google Forms contributes to eco-friendliness. Keeping track of students' progress is made effortless as Google Forms provide a Google spreadsheet with comprehensive individual student analyses.^[23] This organized and readily available data enabled educators to provide meaningful feedback to students, allowing them to invest more time in teaching rather than reviewing answers.

Extensive literature is available on the effectiveness of MCQs, feasibility and reliability of Google Forms, and students' perception regarding the use of MCQs in exams.^[24-27] In the present educational prospective longitudinal study, we consciously made an effort to gather quantitative and qualitative responses to gain deeper understanding of these dimensions.

Limitations and recommendations

This study solely assessed students through MCQ tests, without comparing them to other types of assessments such as short answer questions, short notes, long answer questions, quizzes, etc., Therefore, the students' thought process, reasoning, and potential cueing effects could not be analyzed. To address this, it is recommended that teachers incorporate a variety of assessment methods alongside Google Form-based MCQ tests to ensure a comprehensive evaluation of students' understanding of the subject. Moreover, findings of this study cannot be generalized due to its small sample size limited to a single medical college. However, based on the findings of the study, it is recommended that other medical colleges in India and the National Medical Commission consider the regular use of MCQ tests based on Google Forms as a formative assessment method in medical education to encourage the development of higher-order critical thinking skills among students. Practical issues related to network connectivity or device functionality may occasionally arise for students. However, given the increasing use of technology by students, such issues were not encountered during the study. Developing well-constructed MCQs that align with the criteria of Bloom's taxonomy is a challenging task for teachers. It requires clear teaching objectives, upstream planning, and additional effort from teachers.

Conclusion

A robust student-teacher relationship is of utmost importance in the field of medicine. Educators bear the responsibility of fostering a strong knowledge foundation among students from their first year of medical education, with the aim of enhancing their clinical abilities and preparing them to become competent physicians in the future. Our study concluded that the teachers' extra effort in formulating clinically oriented MCQs and implementing regular Google Form-based MCQ tests as formative assessments in biochemistry played a significant role in helping students overcome their apprehensions about the subject and develop a positive learning attitude toward it. This study also motivated students to actively engage in the learning process, receive valuable feedback, and reinforce their understanding of biochemistry concepts. Remarkably, we observed a measurable improvement in students' IA marks following the implementation of the educational

intervention in the study. Therefore, we advocate for the regular conduction of Google Form-based MCQ tests after every lecture series as a formative assessment tool in biochemistry education among the medical students.

Ethical approval

The Institutional Ethical Committee approved the study (ref. no. SKNMC/Ethics/App/2023/06).

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Nil

Conflicts of interest

There are no conflicts of interest.

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