Short Communication

Blueprints in biochemistry: Systematic assessment in undergraduate medical education

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Abstract

Background: The traditional pattern of theory assessment may not address the principles of assessment due to faulty paper-setting practices. This interventional study aimed to sensitize the faculty in designing a test blueprint template to set question papers (QPs). The set QPs were reviewed by experts to evaluate the effectiveness of blueprinting in the quality of the QPs.

Methods: Based on the validated weightage of the biochemistry syllabus, each of the 10 faculty prepared a test blueprint, and set theory QPs without and with those test blueprints. The QPs were blinded and randomly allocated to 9 experts for evaluation. The test paper review score and feedback from both faculty and subject experts were statistically analyzed.

Results: Reliability check of faculty feedback and review checklist of test papers validated its internal consistency. In all, 95% of participants expressed their agreement with various attributes of blueprinting and its future application in assessment. Statistically significant improvement ($P < 0.005$) was observed in the overall quality of the QPs with blueprinting.

Conclusion: It was determined that blueprinting aligns objectives, content areas, and curriculum with assessment, thus improving reliability and content validity. Validated weightage of the biochemistry syllabus and blueprints for written examination were systematized.

Introduction

In most medical institutes, a traditional pattern for question paper (QP) setting is followed which may not address principles of assessment and may have drawbacks such as subjectivity of paper setter, lack of uniformity, lack of pre-validation, and QP structuring. Patke et al[1] reported a significantly worsened quality of assessment due to compromised attributes of assessment. Such errors resulted in a biased QP which affects the assessment of undergraduate medical students. The overall scenario demands a systematic approach, such as blueprints for the spotted deficiencies. Few interventional studies[2,3] have tried to troubleshoot such issues in the recent past.

This study aimed to align objectives, content areas, and curriculum with assessment for written examinations in biochemistry to improve reliability and content validity. The objectives were to sensitize faculty members about the utility of test blueprints, to prepare test blueprints for summative assessment in the

Biochemistry of I-MBBS, and to evaluate the perception of the faculty for test blueprints as a tool to increase reliability and content validity.

Materials and Methods

Study sesign

With clearance from the Institutional Ethics Committee, this interventional qualitative study was conducted in the Department of Biochemistry at Seth GS Medical College and KEM Hospital, Mumbai, Maharashtra, India, affiliated with Maharashtra University of Health Sciences (MUHS), Nashik. The study was piloted at the department level with the participation of available faculty voluntarily with their written consent.

Study sample
Participation of faculty and subject experts

A total of 10 faculty members in the department with over 5 years of experience were included in the study using convenience sampling. A total of nine subject experts in biochemistry from other medical colleges with over 10 years of experience and experts in blueprinting participated in the study.

Intervention
Setting-up theory QP without blueprinting
Ten faculty were divided into two groups of 5 for Paper-I and Paper-II. The faculty were provided with listed content areas of a syllabus in biochemistry and an assessment scheme. Each faculty was asked to set up one QP for Paper I or Paper II, depending on the group, without blueprinting.

Sensitization of faculty on blueprinting
A one-day Faculty Development Programme (FDP) was conducted in the Department of Biochemistry by an expert in blueprinting from Medical Education Unit (MEU). After the FDP, the faculty compiled, unanimously approved, and internally validated the final weightage for Papers I and II content areas separately based on rating scales after a consensus agreement.

Designing a blueprint for theory QP based on validated weightage
Each faculty prepared theory QP blueprints of Papers I or II in biochemistry using validated weightage.

Setting-up theory QP using a blueprint
The faculty set up one QP of the same Paper I or Paper II with the prepared blueprint.[4]

Review of the QPs by subject experts
The QPs, both without and with blueprints, were blinded and randomly assigned to subject experts for review. Reviews of all QPs were conducted using a semi-structured checklist with pre-validated closed-ended items (Table 1).

Feedback from faculty and subject experts
A pre-validated questionnaire was used to obtain perceptions on blueprinting from both faculty (Table 2) and subject experts (Table 3).

Statistical analysis of the data
Closed-ended questions were evaluated on a 5-point Likert-scale. In the review analysis of QPs, the mean of the Likert-scale rating was subjected to comparative analysis to evaluate the quality of the QP and changes in paper-setting skills of the faculty with blueprinting.

Cronbach's alpha (α) was estimated to find out the internal consistency estimate of the reliability of test scores ($\alpha \leq 0.9$ Excellent, $0.8 \leq \alpha < 0.9$ Good, $0.7 \leq \alpha < 0.8$ Acceptable, $0.6 \leq \alpha < 0.7$ Questionable, $0.5 \leq \alpha < 0.6$ Poor, $\alpha < 0.5$ Unacceptable). Intra-class correlation coefficient (ICC) was calculated to measure a composite of intra-observer and inter-observer variability (r: < 0.40 Poor, $0.40 \leq r < 0.59$ Fair, $0.60 \leq r < 0.74$ Good, $0.75 \leq r < 1.00$ Excellent). Paired t test (2-tailed) was done to analyze QP change quality and paper-setting skills of faculty using blueprint templates. A P value of < 0.05 was considered statistically significant.

Quantitative data were statistically analyzed using Microsoft Excel 2021 and IBM SPSS version 25. Content analysis was performed for open-ended questions by thematic coding of the responses using MAXQDA 12.

Results
Comparative analysis of review of QPs
Reliability analysis of the review of test papers by subject experts resulted in Cronbach's alpha and ICC of 0.890 and 0.881, respectively. This indicates that consistent agreement existed among the reviews of each QP. As shown in Table 4, a comparison of the mean rating score of all QPs before and after blueprinting, reflected a statistically significant improvement in the overall quality of the test papers ($P < 0.005$ by 2-tailed paired t test) for seven faculty. One faculty opted out before completing the paper-setting

Table 1. QP review checklist for subject experts

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
The distribution of questions across topics was uniform in the test papers.					
Test questions were aligned with objectives.					
Test questions were distributed according to 'MK', 'DK' and 'NK' categories.					
Test blueprints tested in-depth knowledge.					
Test questions showed proper weightage to topics of clinical application.					
The test paper showed synchronisation amongst MCQs, SAQs and LAQs.					
Special comments on the distribution of questions across topics in the test paper					
Special comments on the alignment of the questions with the objectives					
Special comments on the distribution of questions according to 'MK', 'DK' and 'NK' categories					
Special comments on the distribution of questions according to 'Recall (50%)', 'Comprehension (25%)' and 'Application (25%)'					
Special comments on the distribution of weightage to the topics in the test papers					
Special comments on synchronisation amongst MCQs, SAQs and LAQs					
Special comments on the overall quality of the test paper					

Abbreviations: DK, Desirable to know; MK, Must know; NK, Nice to know; MCQs: multiple choice questions; SAQs: short answer questions; LAQs: long answer questions

Table 2. Feedback form for faculty

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
Blueprinting helped in maintaining uniformity in the distribution of questions across topics in the test papers.					
Blueprinting kept test questions aligned with objectives.					
Blueprinting standardised distribution of test questions according to 'MK', 'DK' and 'NK' categories.					
Blueprinting tested the in-depth knowledge of the students.					
Blueprinting ensured proper weightage to topics of clinical application.					
Blueprinting helped synchronisation of MCQs, SAQs and LAQs.					
Blueprinting acted as a guide to paper construction.					
Blueprinting increased the reliability and validity of exams.					
Blueprinting is an integral part of the assessment.					
Blueprinting made examination fair and impartial in assessment.					
Which traits of the blueprinting are the most prominent? Are those traits commendable or deplorable?					
What recommendations would you suggest for modification of the blueprints to make the assessment more effective?					
How will you describe your experience while blueprinting test papers during the study?					
Did you face any difficulty while blueprinting the test papers during the study? If yes, please mention those difficulties?					
What impact will the blueprinting have on your assessment methods?					
What probable improvement do you predict in the performance of students with the strategic approach of blueprinting in examinations?					
Would you like to continue the blueprinting for examinations in your department?					

Abbreviations: DK, Desirable to know; MK, Must know; NK, Nice to know; MCQs: multiple choice questions; SAQs: short answer questions; LAQs: long answer questions.

Table 3. Feedback form for subject experts

Items
Which traits of the blueprinting are the most prominent? Are those traits commendable or deplorable?
What recommendations would you suggest to sensitise faculty about blueprinting more effectively?
How will you describe your experience while assessing test papers before and after blueprinting during the study?
Did you face any difficulty in using blueprints while reviewing test papers during the study? If yes, please mention those difficulties.
What probable improvement do you predict in the performance of students with the strategic approach of blueprinting in examinations?
Would you like to continue the blueprinting for examinations in your department? Do state reasons.

with blueprinting, and for two faculty members, there was an improvement in mean review scores, but this improvement was statistically non-significant.

Quantitative data
Reliability analysis of the feedback questionnaire among faculty resulted in Cronbach's alpha and ICC of 0.832 and 0.823, respectively. The consistency of intra-rater and inter-rater agreement was statistically good. Most of the faculty (80%) agreed with the attributes of blueprinting and 90% approved of blueprinting as an integral part of assessment and acknowledged its positive effect on reliability and validity.

Qualitative data
The participants very positively perceived salient features of blueprinting. Most liked the easy distribution of apt weightage and questions across the topics by using blueprints and seconded the feature of proper distribution of marks allotted to questions. Considering marks

Table 4. Comparison of mean rating score of QPs before and after blueprinting

Faculty	Mean Review Score				P value[a]
	Before Blueprinting		After Blueprinting		
	Mean	SEM	Mean	SEM	
Faculty_1	2.93	0.067	3.80	0.186	0.017
Faculty_2	2.30	0.143	3.63	0.490	0.032
Faculty_3	2.33	0.230	3.73	0.113	0.011
Faculty_4	1.87	0.972	-	-	-
Faculty_5	2.03	0.255	3.53	0.322	0.045
Faculty_6	2.30	0.291	3.43	0.306	0.085
Faculty_7	2.30	0.389	3.20	0.339	0.067
Faculty_8	2.47	0.244	3.77	0.155	0.006
Faculty_9	2.97	0.162	4.07	0.135	0.005
Faculty_10	2.60	0.194	4.57	0.179	0.006

Abbreviation: SEM, standard error of mean.
[a] Paired *t* test – 2 tailed.

distribution by recall, comprehension, and application was perceived to be a novel concept. Logic and the embedded strategy of using blueprints to design questions were very well perceived. All faculty and experts wished to continue blueprinting in their departments in the future as a routine assessment activity.

Discussion

As seen in Patke et al,[1] threats to the reliability and validity of the assessment process have been found in summative examination papers in biochemistry in medical colleges. Similar to interventional studies[2,3] conducted in the recent past, this study was initiated on a pilot basis with the stated objectives of troubleshooting such issues to safeguard all the objectives of the assessment in biochemistry.

The blueprinting process is believed to challenge threats to assessment, such as under-representation and construct-irrelevant variance. In the present study, the benefits of the intervention are evident, with an improved quality score of QPs using blueprints and establishment of content validity. Sound blueprinting, with regular necessary revisions and peer review, imparted a positive impact on satisfaction with the acquisition of the learning objectives. Other studies reinforce these findings. Fears of any potential bias that blueprint publication will improve learner performance by driving strategic learning are unsupported, thereby negating this element of bias. The blueprint publication did not improve student performance but did significantly increase the perception of fairness of the evaluation process.

Following similar studies in other medical subjects,[5] the current study's data analysis has undoubtedly reinforced the need for blueprinting for quality assessment in Biochemistry. Feasibility was also established by the study. The implementation of the process for both formative and summative assessment is strongly recommended.

Conclusion

It was concluded that blueprinting can help make the assessment more congruent with the objectives, content area, and curriculum, and can be implemented to improve the reliability and content validity of the assessment. In a phase-wise manner, blueprints can be made available to other medical institutes across the entire state of Maharashtra. In the long run, this well-structured and feasible approach of blueprinting toward setting QPs can be enforced by Health Universities like the MUHS or an apex regulatory agency such as the National Medical Commission.

Future scope

The current study was conducted among a limited number of 10 faculty members. The weightage, though validated, needs to be more widely peer-reviewed by the faculty in medical colleges across the state, which indicates a need for similar state-level study in the future.

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