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Development, Implementation and Initial Evaluation of the Blueprint for MBBS Theory Exams in a Private Medical College of Pakistan

Yusra Nasir, Sobia Ali, Muhammad Ahsan Naseer, Sana Farooq Shah

ABSTRACT

Objective: This study aimed to enhance the validity of the exam bank at Liaquat National Medical College (LNMC), Karachi, through the development and evaluation of the exam blueprinting process as part of an ongoing quality assurance initiative.

Study design and setting: This study was conducted at Liaquat National Medical College (LNMC), Karachi. Participants included key stakeholders i. faculty members, ii-officials from the examination department (involved in the development of the fourth-year MBBS neuroscience exam blueprint), and iii-students.

Methodology: Ethical approval for this study was taken by the LNMC Ethics Review Committee. For the ease of understanding, this article was divided into two sections: In first section, the stepwise approach of blueprint development was discussed whereas the second section dealt with feedback from 105 4th Year MBBS students, feedback from faculty involved in this process and the experiences of examination unit personnel.

Results: Following the Calgary model by Coderre et al., a blueprint for undergraduate MBBS theory exam was developed. Students (85%) agreed that the exam accurately assessed the taught content. Faculty expressed satisfaction with the blueprinting process, noting improvements in exam quality, topic representation, and the elimination of redundant questions. Examination unit personnel reported better time management and improved alignment with curricular objectives. Initial challenges, such as faculty's lack of training and resistance were also identified.

Conclusion: The blueprinting process significantly enhanced alignment of theory exam with educational objectives thereby ensuring the content validity. Continued training and institutional support are vital in overcoming initial challenges and ensuring the long-term success of blueprinting.

Keywords: Blueprinting, Exam Quality, Faculty Satisfaction, MCQs, Quality Assurance, Validity Written theory exam.

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INTRODUCTION

At the core of medical education lies the principle "assessment drives learning." To fully leverage the potential of this principle, it is essential that the assessments themselves are valid, offering a true reflection of a student's competence and understanding. Without such validity, assessments fail to achieve their primary purpose, which is to guide and shape meaningful learning.[1] Traditional assessment designs have their pitfalls, including the subjectivity of the paper setter and frequent complaints from students about the representation of topics.[1] Conversely, blueprint development in medical education offers a systematic multistep approach to assessment, defining purpose (formative/summative and written/practical) and scope (undergraduate or postgraduate students) of the test to subsequently determine the content and method of assessment.[2] It assists in developing assessment more congruent with the objectives, content area, and curriculum, and can be implemented to improve the reliability and content validity of the assessment. This in turn helps in distribution of appropriate weightage and questions across the topics.[3]

The study conducted on undergraduate traditional assessments have identified several shortcomings. Among these deficiencies, a prominent concern is the subjectivity inherent in the formulation of examination papers.[4] Undergraduate medical students have reported dissatisfaction

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with the underrepresentation of themes covered in assessment[5]. Moreover, frequent challenges impacting the content and construct validity of a test may arise from its creation with inadequate coverage of essential learning outcomes or the use of inappropriate assessment tools, leading to irrelevant variability[5].This brings to light the issues of subjectivity, lack of uniformity, and potential threats to the content and construct validity of an exam. These challenges undermine the very purpose of assessments: to accurately measure students' knowledge, skills, and attitudes. Exam Blueprinting address these challenges by reducing construct under-representation (CU) and construct irrelevant variance (CIV) .[5]

A test blueprint defines as:

"*The key elements of a test, including the content to be covered, the amount of emphasis allocated to each content area, and other important features."*[7]

An exam blueprint in medical education serves as a crucial tool for mitigating major threats to validity in assessments. The alignment offered by blueprint connects the three foundational pillars of education: structured learning objectives, teaching and learning activities, and assessment tasks.[6] By utilizing a blueprint, educators can ensure that these pillars are harmoniously aligned, leading to more effective and valid assessments. They also provide valuable metadata for managing Multiple Choice Questions (MCQs) bank. Once test items are coded according to a blueprint, it becomes easier to retrieve them from a larger pool of items and assemble them into various test forms for different purposes.[7]

One of the study investigated the impact of implementing an exam blueprint on student performance and satisfaction in a basic imaging module showed that students who were assessed in an exam using blueprints outperformed those who were not, with statistically higher scores, greater satisfaction, and improved achievement of learning outcomes.[8]

The literature describes the blueprinting development process in several key stages: (1) clearly defining the purpose and scope of the assessment; (2) identifying the primary domains of knowledge and skills to be evaluated; (3) outlining the objectives or learning outcomes to be assessed within each domain for each topic; (4) selecting the appropriate assessment format; and (5) assigning specific weights to each content category, such as knowledge and skills domains.[9] Despite the clear advantages of using a test blueprint in assessment, certain challenges persist. These include the lack of a standardized approach to blueprint design, and incomplete awareness among test developers about the importance and effectiveness of test blueprints.[10]

The Examination Unit (EU) at Liaquat National Hospital & Medical College (LNMC), Karachi, involved in exam development since its inception in 2012. It was highlighted through frequent exam feedback that the theory exam faced the issues of content distribution. As a result EU undertook a continuous quality assurance process. This process prioritizes exam validity by incorporating recent evidence-based recommendations while considering the contextual challenges and enablers. A one-year revision focused on the creation of new blueprints for the multiple-choice question assessments was done as part of this continuous quality assurance process.

Objectives: This article aims to:

1. Outline a methodical approach towards blueprint development for a written examination.

2. Explore the experiences and satisfaction of faculty and examination department officials involved in the blueprinting process.

The article will conclude with a discussion proposing a way forward for further advancing the exam blueprint development process in other domains of assessment.

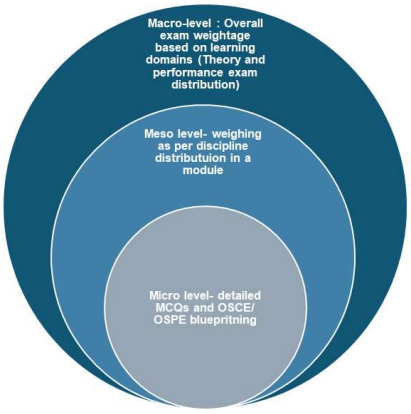
METHODOLOGY

To conduct this research, we gathered data from multiple sources that includes stepwise blueprint development process, surveys, and interviews. For the ease of understanding, this quality assurance process will be delineated in two sections; the first section will deal with the process that we follow for blueprint development and second section will deal with the experiences and satisfaction with the process of major stakeholders of this endeavor.

1) *Blueprint development process*

Blueprints were formulated through a three-tiered approach; at first theory and performance exam distribution was decided for each module (Macro level; figure 1) after that weightage of each discipline in the module was identified (Meso level; figure 1) and finally the third layer was developed in which the detailed distribution of MCQs and OSCE was made along with the specification of their topics and subtopics (Micro level; figure 1).

Figure-1: Blueprinting Process across Macro, Meso and Micro Levels



To explain the blueprint development process at our institution, we will use the example of Year 4 MBBS Neuroscience module. This process took six month from Blueprint development to its evaluation by stakeholders. The following steps were employed to construct the blueprints.

The process started with the repetitive training sessions for faculty (basic and clinical sciences) involved in the exam development at college. The sessions targeted specifically hands-on practice on the various models of blueprints. With the collaborative effort of exam unit, and module committee (included the faculty involved in the module development and implementation), blueprints were developed at three levels as follows:

Step 1: Weightage according to learning domains (Macro-level)

The first step in this process was to map the curriculum to identify the content coverage of knowledge & skill components in the module. A detailed review of learning objectives was done to identify their domains, and levels that will help target the path toward assessment validity claim.[8] The process started when faculty were working together for module development. This first layer of the blueprint consisted of a broad division of content in terms of knowledge and skills domains. The weightage (table 1) was calculated based on hours allocation and importance of objectives (as prescribed by the faculty) to be covered for that module.

Step 2: Discipline-based weightage of exam content in a module (Meso-level)

This layer of blueprint was developed for ensuring the adequate weightage for individual discipline in a module. Before this stage, the weighting of a content area has already been established through consensus (based on its importance) during module development meetings. The weightage of this layer is simply based on hour allocation as described by Abdellatif and Al-Shahrani.[11] Discipline wise weightage distribution in the theory exam of Neuroscience module is presented in Table 2.

Step 4: Detailed description of MCQs with objective alignment

The third layer encompasses the detailed attributes of multiple-choice questions (MCQs) for each identified topic or disease within each discipline. The blueprint model employed the development of this layer using the impact x frequency model (Table 3.1) outlined by the University of Calgary in the literature.[12,13] Through a consensus-building process involving subject specialists, impact and frequency were calculated, which subsequently determined the weight of each item. Further item descriptions were finalized by revisiting the objectives to ensure alignment. For instance, five questions were determined for headache, with diagnosis, investigation, treatment, complications and prognosis options identified as the essential knowledge areas to be assessed as shown in Table 3

Table 1: Learning domain division in neuroscience 4th year MBBS module

Neuroscience Module	
Knowledge	**Skills**
62%	38%

Table 2: Discipline wise weightage distribution of Neuroscience module Theory exam

Subjects	Teaching Hours	Weightage	No. of MCQs
Neurology	25	28%	42
Pediatrics	5	6%	8
Pathology	20	22%	34
Pharmacology	20	22%	33
Psychiatry	10	11%	17
Neurosurgery	8	9%	13
Radiology	2	2%	3
Total=T	T= 90	T=100%	T=150

2) Experiences & Satisfaction with the process: The satisfaction with the process was done by using three evidences:

i. Taking feedback from students about the content validity of the exam

ii. Taking feedback from faculty involved in the process by doing a survey

iii. In depth interview from exam unit personnel

Ethical approval for this study was granted by the Liaquat National Hospital Ethics Review Committee (1020-2024-LNH-ERC). Feedback was collected from students regarding the content validity of the exam. A total 105, 4th year MBBS students were asked the question in post exam survey taken after the module exam. The question been asked was, "Did the module examination accurately assess the taught content?"

Faculty feedback was taken in the form of questionnaire from those involved in blueprinting process of the module and these included Professors, Associate & Assistant Professors from both clinical and basic sciences, all with backgrounds in medical education training. The sample size was calculated using the Online OpenEpi Version 3 tool. For a population size (N) of 33, it was hypothesized that the outcome frequency in the population would be approximately 50%, with a margin of error of ±5% and a confidence level of 95%. Based on these parameters, a sample size of 31 individuals was calculated. A Likert scale-based survey was developed by a medical educationist and reviewed by three medical education experts. The survey was administered via Google Forms to 33 faculty members involved in the exam blueprint development for the year 2023.

Table 3: Distribution of multiple-choice questions (MCQs) for each disease within Neurology

Theme	I	F	I*F	IxF/T	Weightage (Tx42)	No of items	Patho-physio	Diagnosis	Investigations	Treatment / Management	Complications	Prognosis
CNS Infections / Meningitis	3	2	6	0.11	4.9	5	✓	✓	✓	✓ ✓		
Coma	2	2	4	0.07	3.2	3		✓	✓	✓		
Cranial nerve lesions	2	1	2	0.03	1.6	2		✓	✓			
Dementia	1	1	1	0.01	0.8	1		✓				
Epilepsy/Seizures	3	2	6	0.11	4.9	5	✓	✓	✓	✓	✓	
Guillain-Barre syndrome	2	3	6	0.11	4.9	5		✓	✓	✓	✓	✓
Headaches	3	2	6	0.11	4.9	5		✓	✓	✓	✓	✓
Movement disorder	1	1	1	0.01	0.8	1	✓					
Lesion localization	1	1	1	0.01	0.8	1	✓					
Parkinson's Disease	3	1	3	0.05	2.47	1		✓				
Muscular dystrophies	1	1	1	0.01	0.8	1			✓			
Multiple Sclerosis	2	1	2	0.03	1.6	2		✓	✓			
Myasthenia Gravis	3	2	6	0.11	4.9	5			✓	✓	✓✓	✓
Stroke	3	3	9	0.17	7.4	7		✓	✓	✓	✓	✓
			51		42.7	42						

Table 3.1: Impact and frequency descriptors

Score	Impact Description	Frequency Description
1	Non-urgent, little prevention potential	Rarely seen
2	Serious, but not immediately life threatening	Relatively common
3	Life threatening emergency and/or high potential for prevention impact	Very common

At the end, three in-depth interviews (IDIs) of 30-40 minute duration were conducted with exam officers and the examination in-charge using a pre-developed interview guide. In-depth interviews were conducted until we achieve the theoretical saturation, following the recommendations of Corbin.J, Strauss A.[14] Interviews were audio-recorded and transcribed verbatim using Microsoft Office 365, ensuring confidentiality and anonymity. Transcripts were anonymized before data analysis. Credibility of responses was ensured by summarizing the responses at the end of interview as well as by member checking after transcription. Privacy and confidentiality of all the participants and their responses was maintained throughout the data collection and analysis process.

Data Analysis

I. A descriptive analysis using SPSS version 23 was done to gauge the percent of agreement from feedback from both students and faculty.

II. In-depth interviews (IDIs) with personnel from the examination unit were analyzed using manual thematic analysis.[15] Braun & Clarke's thematic analysis methods were used to identify, organize, describe, and report themes found within the data set.[16] After multiple readings of interview transcripts, the researchers assigned codes based on the interview questions and responses. Through an iterative process of examining and re-examining the coded excerpts, themes were identified along with key quotes to develop evidence-based narratives and recommendations.[17]

RESULTS:

After development and implementation of the theory exam blueprint as described above, the students' and faculty feedback survey was conducted and exam officers' experiences were measured through interviews.

I. Students feedback:

With a response rate of approximately 96.2%, eighty five

Table 4: Faculty level of agreement on the Blueprinting Process for Exam Development

Statement	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)
I was provided clear guidelines for the blueprinting process	0	0	10	50	40
I was provided with sufficient resources & tools (study guide & time tables) for blueprint development	0	0	13.3	36.7	50
I understood the Blueprint template/model easily.	0	0	23.3	43.3	33.3
I was given full opportunity to develop my subject's blueprint	0	3.3	6.7	43.3	46.7
I believe that blueprint has significantly enhanced the quality of MCQs.	0	0	6.7	50	43.3
I feel confident while utilizing formulated blueprints for my subject's exam preparation.	0	0	0	53.3	46.7
I believe that blueprinting ensured well balanced distribution of MCQs across topics.	0	0	10	53.3	36.7
I believe that Blueprinting has improved alignment of the MCQs with course objectives	0	0	3.3	70	26.7
I believe that overall process of paper setting has become simplified after blueprint development.	0	0	6.7	53.3	40
I acquired a comprehensive understanding of exam development through my active involvement in the blueprinting process.	0	0	6.7	46.7	46.7

percent of the students showed agreement to the question being asked about the content validity of the exam (N=101)

II. Faculty feedback: Feedback survey was filled by the 31 faculty members with a 100% response rate. The departmental representation for blueprinting included a mix of clinical and basic sciences faculty members, with designations ranging from Assistant Professor to senior positions.

Table 4 summarizes the levels of agreement for ten statements related to the blueprinting process for the development of theory examination. Overall, the survey results indicated a highly positive response to the blueprinting process across various specialties.

In-Depth Interviews: In-depth interviews were conducted from in-charge of the examination unit (IEU) and two senior exam officers (SEO) to explore their experiences, challenges, and the impact of blueprinting on exam development which are highlighted in Table 5.

DISCUSSION:

This study offered insights into the extent to which blueprinting can markedly enhance the quality and alignment of exams with course objectives, ensuring that assessments are both comprehensive and closely tied to the curriculum. The student's survey revealed a high level of agreement (85%) regarding the content validity of the exam, indicating that students perceived the exams as closely aligned with the taught material. This is consistent with findings from previous studies where MBBS students expressed satisfaction with exam blueprints that ensured appropriate question distribution and alignment with learning objectives.[2,18] In a study conducted in 2023 by Dutta & Goswami, MBBS students demonstrated satisfaction with the biochemistry exam blueprint, which was praised for ensuring content validity, construct reliability, and fairness over two academic years.[18]

The faculty survey results from this study showed that most faculty members were satisfied with the blueprinting process, particularly regarding the clarity of guidelines and the availability of resources. This positive feedback suggested that blueprinting simplifies the exam development process and making it more efficient and aligned with educational objectives. These findings are consistent with existing research, which indicated that faculty members value clear and structured exam blueprints as they enhance the alignment between teaching and assessment, ultimately improving educational outcomes.[2] Additionally, in 2022, Chrisyarani et.al. found that faculty satisfaction is significantly influenced by their involvement in the blueprinting process, highlighting that participatory approaches can improve perceptions of fairness and relevance in assessments.[19]

The in-depth interviews with examination officers and in-charge revealed several key benefits of blueprinting, including improvements in time management, ease of question selection, and better alignment of exams with curriculum objectives. These findings are supported by Bhardwaj's study that emphasizes blueprints are essential for aligning content with curriculum objectives and ensuring comprehensive assessments.[20] The interviewees highlighted the elimination of redundant questions and improved

Table 5: Examination Officers' and In-Charge's Perspectives on the Blueprinting Process

Theme	Sub-Theme	Verbatim Quotes
Shifts in Exam Development Approach	Time Management Improvements	"Benefit of time management for exam development was evident"??... *(IEU)*
	Ease of Question Selection	"The exam development has become easier. Faculty (Content experts) used to visit DHPE and select questions randomly from taught topics"?? *(SEO_1)* "Previously the practice was... the question were being selected by the faculty randomly from the subtopics and topics"??.. *(IEU)*
	Balanced Representation of Topics	"The risk of out of course exam was reduced significantly after Blueprinting" *(SEO_2)* "After BP the exam is reflecting timetables and study guides... previously the exam was under or over represented and some areas were entirely skipped"??*(IEU)*
	Appropriate Weightage Assignment	"Now what we have seen is that the proper weightage has been given to all the topics as we wanted from the start of the process"?? *(SEO_2)* "Previously the proper weightage was not given in the blueprint….. It was not there before"?*(SEO_1)*
	Objective Alignment & Curriculum Reflection	"This time we know the objectives and their weightage in assessment"? *(SEO_1)* "The topics in the exam paper are exactly what the reflection of the study guide"?
	Elimination of Redundant Questions	"Duplications of questions has been reduced" *(SEO_1)*?? "The overlapping was there, the duplication was there in the exam... these weaknesses which used to be there previously are rectified this time after developing of the blueprint""*(IEU)*
	Faculty Satisfaction	"This time faculty didn't complain"?? *(SEO_1)* "Faculty has mentioned numerous time in the meetings that significant difference in the exam results has been seen, as a result of proper exam development"*(IEU)*
Needs and Challenges	Initial Lack of Training	"Faculty needs proper training for that. Up till now the faculty has been trained pretty much but still there is a need of some kind of proper training"??*(SEO_2)*
	Resistance from Faculty	"As far as my department is concerned my department faculty is already trained. I just had to guide... But if you talk about college faculty. There was some resistance"?? *(IEU)*
Provision of Support & Resources	Departmental Support	"I collected the timetable and study guide, which were essential for preparing the Blueprint, with full support from the DHPE faculty and administrative staff." (*SEO_2)*
	Faculty Support	"There was strong teamwork throughout the process, with valuable support from both the medical college faculty and DHPE staff." *(SEO_1)*
	Institutional Support	"I received full institutional support and all the necessary resources right from the very beginning, and that support continues to this day." *(IEU)*
Suggestions for Future Improvement	Increasing Question Bank Size	"Adequate no of questions should be there in future against the developed BP at least three questions against one sub-theme"?? (*SEO_2)*
	Clarifying Study Guide Objectives	"Next time what we can do is... the objectives are still in the study guide needs to be clearly mentioned so that we can exactly identify the content*"??(SEO_1*

reflection of the curriculum, which aligns with the work that emphasize the role of blueprinting in enhancing the coherence and relevance of assessments.[21] Furthermore, the interview identified key challenges in the implementation of blueprinting, primarily due to the initial lack of support from faculty. This resistance was largely due to unfamiliarity with the blueprinting process and concerns about the perceived additional workload. These findings align with existing

literature which highlighted that exam officers often face challenges due to resource limitations, including insufficient training of faculty.[22] Such limitations can significantly hinder the creation of effective blueprints and the smooth implementation of the process. Overcoming this resistance required targeted efforts to familiarize faculty with the benefits and procedures of blueprinting.

Limitations of the study: As the data is derived from a single site, this limit this study. Additionally, our feedback data, consisting solely of faculty self-ratings, may not accurately reflect actual practices. Despite these limitations, we believe this study warrants publication as it offers valuable guidance and a framework for developing a valid exam bank, particularly within the curricular structure in Pakistan. Ongoing research by the authors on the blueprinting of assessment of skills and attitudes and its impact on students' learning will provide further elaboration.

CONCLUSION:

This study outlined a methodical approach to the quality assurance process of written examinations within an undergraduate medical curriculum, guiding the development of a reliable bank of multiple-choice questions (MCQs). The experiences and satisfaction of the faculty and examination department officials highlighted the notion that exam blueprints are instrumental in aligning exams with educational objectives, thereby improving the quality and effectiveness of assessments. Additionally, the importance of clear guidelines, adequate resources, and strong institutional support are critical in the successful implementation of such an endeavor. While initial challenges were present, the overall positive outcomes indicated that blueprinting was a valuable tool in educational assessment, contributing to the validity and fairness of exams.

Moreover, it is recommended that providing continued training, coupled with institutional support, is essential for establishing and sustaining initiatives to build validity evidence of exams through the blueprinting process. In addition, there is a need to investigate the long-term effects of blueprinting on student outcomes and faculty satisfaction.

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Yusra Nasir: Data acquisition, analysis and interpretation, Drafting, revising & Final review of Manuscript
Sobia Ali: Substantial contributions to conception and design, analysis and interpretation of data, Drafting, revising & Final review of Manuscript
Muhammad Ahsan Naseer: Data acquisition, analysis and interpretation, Drafting of manuscript
Sana Farooq Shah: Conception of study, data acquisition, analysis and interpretation

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