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#### **Research Article**

# Post-Validation of Multiple-Choice Questions in Microbiology

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#### ABSTRACT

**Background:** Multiple Choice Questions (MCQs) are used to help understand the strengths and weaknesses of students and gaps in knowledge and provide feedback to teachers on their teaching methods. MCQs, therefore, should be valid and reliable. The statistical analysis of MCQs/items is done post-validation to check that they can adequately evaluate students' learning.

**Methods:** A retrospective observational study of 72 solved MCQs was used for item analysis. Parameters that were analyzed included Difficulty Index (DIF), Discrimination index (DI) and Distracter effectiveness (DE).

**Results:** Difficulty Index was 54.17% easy, 34.72% acceptable and 11.11% difficult. The Discriminatory Index (DI) calculation showed that 93.05% were poor, 3% acceptable, and 4.16% good. Among the MCQs with poor discrimination, there were 37.5% MCQs had negative discrimination, as low achievers answered these MCQs more than high achievers. The total number of distractors analyzed was 216 and the number of Non-Functional Distractors was 75 (NFD, those selected by < 5% of students), and functional distractors (FD) were 141(those chosen by >5% of students).

**Conclusion:** An MCQ is ideal when it satisfies all three criteria, such as acceptable DIF 30-70 and acceptable DI 0.21-0.35, and has three functional distractors. In our study, only one MCQ satisfied acceptable DIF, DI and had three functional distractors.

**Key-words:** Post-validation, Multiple choice questions (MCQs), Difficulty Index (DIF), Discrimination index (DI), Distractor effectiveness

#### INTRODUCTION

Formative assessments are an integral part of the MBBS curriculum. Multiple choice questions (MCQs) have been part of assessment and short answer and essay questions for many years. Since 1999, multiple-choice questions (MCQs) have been used for university and competitive examinations in medical education.

MCQs help to understand the strengths and weaknesses of students and gaps in knowledge and provide feedback to teachers on their teaching methods. Assessment becomes an integral part of learning as learning is driven by assessment<sup>[1-3]</sup>.

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Access this article online https://iijls.com/ Assessment, therefore, helps to understand the effectiveness of the teaching-learning program <sup>[4]</sup>. Knowledge assessment uses methods like essays, short answers, short answers, and multiple-choice questions (MCQs) <sup>[5]</sup>. Well-structured MCQs help to assess students' higher cognitive knowledge, such as interpretation, synthesis, and application of knowledge, instead of just testing recall of isolated facts. They can test large content in a short time <sup>[3,5,6]</sup>. MCQs, therefore, should be valid and reliable <sup>[2]</sup>.

Standard pre-validation and post-validation protocols are recommended to increase MCQs' validity and reliability <sup>[3]</sup>. Pre-validation is done before administering the MCQs. In pre-validation, a committee of three or four subject experts checks the construction of each item <sup>[4]</sup>. Postvalidation done after the student takes the exam is also called item analysis. The statistical analysis of MCQs/items to check that they effectively evaluate students' learning is done during post-validation <sup>[4]</sup>.

Item (MCQ) analysis examines each student's responses to test items. It helps to assess the quality of those MCQs, and the test conducted <sup>[6]</sup>. Re-structuring or deleting the poorly constructed MCQs can be done <sup>[6,7]</sup>. After documenting the student responses, using the Difficulty index (DIF), Discrimination index (DI), and Distracter effectiveness (DE), the quality of MCQs is assessed <sup>[3,8]</sup>. The difficulty index refers to students' difficulty while choosing the correct answer to a given question <sup>[8]</sup>. An item was considered difficult when the value of the difficulty index was less than 30% and the item was considered easy when the index value was greater than 70% <sup>[7]</sup>. The discrimination index indicates how effectively an MCQ discriminates high achievers from low achiever students. It ranges from 0 to 1. Higher the DI of an MCQ, the better the discriminatory capacity. MCQs with DI ≥0.20 were considered ideal, meaning that particular MCQs could differentiate high achievers from low achievers. The items with a negative discrimination index (D) ranging from 0.0 – 0.19 were to be discarded or modified, <sup>[7]</sup>. Distracter efficiency describes the ability of each of the provided answer options to distract students from the correct answer, and they are considered functioning distracters <sup>[8,3]</sup> A Functioning distracter (FD) indicates that >5% of students have chosen a particular wrong option as an answer and hence were a good distracter <sup>[8]</sup>. There are several studies on item analysis, but such analysis of MCQs has not yet been done in the Department of Microbiology of Terna Medical College, so the data generated can be used regularly to test the quality of the MCQs. This study was therefore planned to get validated MCQ bank and help in faculty development.

## MATERIALS AND METHODS

**Methodology-** A retrospective observational study of solved MCQs of second MBBS students of Microbiology was conducted from 2017 to 2018. Second, MBBS students have 3 internal exams in their professional year in Microbiology as part of their formative /summative assessment. MCQs are an integral part of these assessments. Terminal exams 1 and 2 had 20 MCQs each and term 3 exams had paper I & II, which had 16 MCQs each. 72 MCQs from solved MCQ answer sheets were used for item analysis and 216 options were considered for distractor efficacy. A correct response to an item was awarded one mark and the wrong MCQ zero mark, and no negative marks were allotted.

**Exclusion Criteria-** Students who did not appear for any one exam were excluded.

**Statistical Analysis**- The data obtained were entered in MS Excel, and the scores of 105 students were arranged in descending order and were divided into 3 groups. The upper  $1/3^{rd}$  (35) of the total students was labeled as high achievers (H) and the lower  $1/3^{rd}$  (35) of the total students were labeled low achievers(L) and Middle  $1/3^{rd}$  (35) was discarded <sup>[9]</sup>. Based on the data collected following parameters were analyzed;

a) Difficulty Index (DIF I) = <u>(H+L)</u> x100 N

where,

H-Number of the students answering the MCQs correctly in the high group

L-Number of the students answering the MCQs correctly in the low group

N-Total number of the students in two groups, including the non-responders

c) Distracter effectiveness (DE)-% of students, who choose the wrong option instead of the correct answer.

Table 1 shows the criteria for describing the MCQs based on cut-off value for the purpose validation of MCQs  ${}_{[3,7,9,11]}$ .

**Ethical Approval-** Approval from the institutional ethics committee was taken before conducting the study.

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Parameter	Formula	Cut-off value	Interpretation
Difficulty index (DIF I)	(H+L/N)*100	<30%- Difficult	Higher the DIF index the
		31-70-Acceptable	easier is the MCQ
		>70 Easy	
Discrimination index	2 X[(H-L)/N]	DI ≤0.19 Poor	If the DI is higher, the
(DI)		DI 0.20-0.39 Acceptable	MCQ can discriminate
		DI≥0.4 Excellent	between high achievers
			and low achievers.
Distracter effectiveness (DE)	% of students who choose the wrong option instead of the correct answer	<ul> <li>If &gt;5% of students choose a particular option other than the answer, then that choice is considered a Functional distracter</li> <li>If &lt;5% of students choose a specific option other than the answer then that choice is considered a Non-Functional distracter</li> </ul>	

Table 1: Interpretation of DIF-I. DI and DE

H= Number of students answering the MCQs correctly in the high group L= Number of students answering the MCQs correctly in the low group

N=Total number of students in both H and L, including the non-responders

#### RESULTS

A total of 72 items (MCQs) were analyzed and the mean Difficulty Index (DIF I) (Table 2) was 61.47, with a standard deviation of 22.37, which means MCQs were easy. There were 54.17% (39 MCQs), which were considered easy, 34.72% (25 MCQs) acceptable, and 11.11% (8 MCQs) difficult.

Table 2: Difficulty	index	of the	MCQs
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, ,			
Cut off points	Total number	Interpretation	
of DIF I	of Questions		
>70	39(54.17%)	Easy	
30-70	25(34.72%)	Acceptable	
<30	8(11.11%)	Difficult	
Total	72	-	
Questions			
Mean	61.47	Easy	
Standard	22.37		
Deviation			

The calculation of the Discriminatory Index (DI) of the MCQs showed that 93.05% (67 MCQs) were poor, 3% (2 MCQs) acceptable, and 4.16% (3 MCQs) good (Table 3).

Among the MCQs with poor discrimination, 27 (37.5%) questions had negative discrimination; low achievers answered these more than high achievers. The mean Discriminatory index in this study was 0.036 with a standard deviation of 0.112, which can be interpreted as the majority of MCQs having poor discrimination ability.

Table 3:	Discrimination	index o	f MCQs
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Cut off points	Number of questions (%)	Interpretation
≤0.19	67(93.05)	Poor
	27(37.5)	Negative discrimination
0.20-0.39	2(3)	Acceptable
DI≥0.4	3(4.16)	Excellent
Total Number of	72	
Questions		
Mean Standard deviation	0.036 0.112	Poor

The analysis of the difficulty index and discrimination index together (Table 4) shows that among the 54.17% (39) easy MCQs, 52.8% (38 MCQs) had poor discrimination and one had acceptable discrimination. Among the 34.72% (25) acceptable MCQs, 29.17% had a poor discriminatory index and among the 11.11% (8)

MCQs) difficult MCQs, all had a poor discrimination index.

Coefficient of MCQs			
Difficulty index	Discriminatory	Number (%)	
Easy MCQ=39	Poor	38(52.8)	
	Acceptable	1(1.38)	
Acceptable MCQ	Poor	21(29.17)	
25	Acceptable	1(1.38)	
	Excellent	3(4.16)	
Difficult MCQ	Poor	8(11.11)	

(n=8)

 Table 4: Comparing Difficulty and Discriminatory

 Coefficient of MCOs

The total number of distractors analyzed was 216, as shown in Table 5. The total number of functional distractors (those selected by >5% of students) was 66.2% i.e. 141 distractors which included 47 MCQs. 12.5% (9 MCQs) had 3 Functional Distractors (FD) and had a Distractor efficiency of 100%, which means all options were close to correct answers and hence worked to distract students. MCQs with 2 FD were 26.39% (19 MCQs) and DE of 66%. Another 26.39% (19 MCQs) had 1 FD and DE of 33%, and Non-Functional Distractors (those selected by <5% of students) was 33.38% i.e. 75 distractors from 25 MCQs had no FD with 0% DE.

## Table 5: Distractor analyses of MCQs

Type of Distractors	Number of MCQs (%)	Total number of Distractors (%)
**Total number of FD	47(65.28)	
<ul> <li>Number of MCQs that</li> </ul>		
had 3 Functional	9(12.5)	
Distractors (100% DE)		
<ul> <li>Items that had 2</li> </ul>	10/26 20)	
Functional Distractors	19(20.59)	141(66.2)
(66% DE)		
<ul> <li>Items that had 1</li> </ul>	19(26.39)	
Functional Distractors	()	
(33% DE)		
*Total number of NFD	25(34.72)	75 (33.8)
(0% DE)		
Total number of	72	216
distractors analyzed		

\* Non-functional distractors (NFD those selected by < 5% of students)</li>
 \*\* Functional distractors (FD those selected by >5% of students)

Comparing distractor, difficulty and discriminatory index is shown in Table 6. A total of 34.72% of MCQs (25

MCQs) with NFD had DIF as easy MCQ with poor discriminatory index and 26.39% of MCQs (19 MCQs) had 1FD were also easy MCQs with poor DI. MCQs with 2 FD were 26.39% (19 MCQ), of which 17 had acceptable DIF but poor DI. 12.5% of MCQs with 3 FD had one MCQ with acceptable DIF and DI and 8 MCQs had difficult DIF but poor DI.

Table 6: Comparison of distractors, difficulty and
discriminatory index

MCQs (%)	Distractors	DIF	Discriminatory
25(34.72)	NFD	Easy-25	Poor
19(26.39)	1FD	Easy -14	Poor
		Acceptable- 5	Poor
19(26.39)	2FD	Easy -2	Poor
		Acceptable 17	Poor
9(12.5)	3FD	Acceptable- 1	Acceptable
		Difficult-8	Poor
Total-72		Total 72	

# DISCUSSION

The mean Difficulty Index in the present study is 61.47, of which acceptable MCQs were 34.72%. Results of a study done by Mitra *et al.* <sup>[7]</sup> showed DIF ranging from 64%-74% and Balaha *et al.* had a mean DIF of 0.71 of which 46% were easy and difficult questions 11% <sup>[8]</sup>. However, a study conducted by Pande *et al.* <sup>[9]</sup> had only 23% easy MCQ in contrast to 54.17 % in our study. Their study had 15% of the items difficult, and 62% of the items had acceptable difficulty indices. A study by Jaison *et al.* had 50% easy and 50% acceptable MCQs and no difficult items <sup>[3]</sup>. The study by Patil *et al.* showed that 46.7% of the MCQ was acceptable and 36.7% difficult <sup>[10,11]</sup>.

A good discriminatory index that is required to discriminate between high and low achievers is >0.20. The mean Discriminatory index in this study was 0.036, which means the majority of the MCQs in this study had low discrimination capacity. The poor discriminatory index ( $\leq$ 0.19) in this study (93.05%) was because there were 27 items with negative discrimination Ahmed *et al.* <sup>[6]</sup> mention that few studies have item discrimination indices ranging from -0.54 to 0.8. Gajjar *et al.* <sup>[12]</sup> reported that 52% of questions with poor discrimination. Jaison *et al.* <sup>[3]</sup> had 40% of MCQs with poor discriminatory index ( $\leq$ 0.19). Pande *et al.* <sup>[9]</sup> study had 4%

negative discrimination and 21% of the MCQs were of poor discrimination index where, whereas Mitra *et al.* <sup>[7]</sup> had 20% of MCQs with poor DI. However, none of the studies had a low degree of discriminatory index or negative discrimination compared to the present study. This indicates that the MCQs need to be revised for future use and the stem of the item, which was poorly constructed, needs to be reviewed and more expertness is needed by the faculty while making the MCQs.

This study analysis of difficulty and discrimination coefficient revealed that only 5.55% (4 MCQs) MCQs satisfied the criteria of acceptable difficulty index and acceptable-good discrimination. Habib *et al.* found that the discrimination index and difficulty index correlate weakly with each other <sup>[4]</sup>. The poor discriminatory index in this study could be because of ineffective distractors or poorly constructed stems.

Having three distractors makes most of the items difficult. Having two distractors makes most of the items very good and having only one distractor makes most of the items easy <sup>[13]</sup>. MCQs of our department exams did not have any distractors and all these belonged to the easy. Gajjar *et al.* <sup>[12]</sup> and Mukherjee *et al.* <sup>[13]</sup> concluded similar results and stated that more NFDs in an item increases DIF I (makes the item easy) and reduces DE.

## CONCLUSIONS

An MCQ is considered ideal when it satisfies all three criteria: acceptable DIF 30-70, acceptable DI 0.21-0.35 and with three functional distractors. In our study, only one MCQ satisfied acceptable DIF DI and had three functional distractors. MCQ analysis is critical in assessing students' in-depth knowledge. In many situations, teachers set an easy paper to improve students' scores, but this fails to discriminate between high achievers and low achievers and weakens the test quality. In this study, even though the number of easy questions was higher, there were an adequate number of good, excellent, and difficult MCQs. However, the concern in this study is regarding the poor discriminatory index.

This indicates the need for content experts to review each item so that the quality of the test can be improved along with a justified assessment. The data generated in this study will help to initiate a change in the way we select our future MCQ items. CONTRIBUTION OF AUTHORS Research concept- Dr Anila Prabil Research design- Dr Anila Prabil Supervision- Ms Lini Materials- Dr Anila Prabil Data collection- Ms Lini Data analysis and Interpretation- Dr Anila Prabil Literature search- Ms Lini Writing article- Ms Lini Critical review- Dr Anila Prabil Article editing- Ms Lini Final approval- Dr Anila Prabil

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