

Learning Gains Through Multiple Choice Questions in Physiology

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ABSTRACT

Introduction: Assessment of students is an integral part of medical education. The assessment of cognitive domain in traditional medical curriculum, involves Constructive response type of questions. However for the high stake examinations, the students are exposed to MCQs, a Selective response type of questions. Innovative medical curriculum has been successfully utilising MCQs for assessment of students' performance. The purpose of this study was to evaluate the learning gains in Physiology using MCQs for formative assessments.

Material and Methods: The study was a cross sectional, observational, analytical study with a sample size of 52 MBBS students, exposed over 3 sets of Single Response Multiple Choice (MCQ) and Single Response Problem Based Questionnaires (PBQ) in Physiology. The test scores were recorded and absolute and relative learning gains were calculated and statistically analysed ($P < 0.05$ as significant) to study the outcome measures.

Results: One tail t test confirmed statistically significant absolute and relative learning gains. Pearson's Product Moment Correlation Coefficient "R" also indicated a positive correlation between MCQ and PBQ.

Conclusion: This study clearly revealed that MCQ and PBQ can produce learning gains for MBBS students in Physiology. Therefore, if medical educators, policy formulators and implementers design an integrated medical curriculum with MCQ and PBQs as assessment tools there would be significant absolute and relative learning gains for medical students. The same study, when applied for other disciplines in a similar curriculum in the same setting, bear the potential to yield similar learning gains.

Keywords: Learning Gain, Absolute Learning Gain, Relative Learning Gain, MCQ, PBQ.

INTRODUCTION

Assessment and evaluation, integral aspects of education, are not only critical but also involve an elaborative process. Hence it becomes imperative that the continuous activity of assessment and evaluation should be developed simultaneously and at par with the Curriculum Designing.¹ The most powerful educational device is a well planned curriculum with well defined assessment and evaluation processes.² The cardinal requirement of medical education is accurate assessment to reach expected outcome. Various assessment processes in medical education are Theory, Practical, Clinical and Oral Examinations. Multiple assessment procedures have a varied yet powerful influence over the learning process.³⁻⁷

In written examination, the cognitive domain of undergraduate medical students are tested with selected response type e.g. Multiple Choice Question (MCQ) and constructive response types e.g. Short Answer Question (SAQ), Modified Essay Questions (MEQ) and Long Answer Questions (LAQ).⁸⁻¹⁰ The Constructive Response type of Essay questions provide scope for evaluation of communication skills as well as various cognitive levels specified by Bloom.¹¹⁻¹³ The Selected Response item

format, developed nearly a century ago provided an efficient means of cognitive testing for large group of examinees. Ebel (1972)¹⁴ in his brief history of development of MCQ format stated that the US Military first used this format in the early twentieth century, for recruit selection testing. The MCQ's are the most common type of assessment tools for their reliability, validity and ease of scoring.¹⁵⁻²¹ The validity, reliability, item analysis and other quality control methods for MCQ tests were studied and established over a period of time.²²⁻²⁴ Nnodim²⁵ reported that MCQ papers were less sensitive predictors of the aggregate performance compared to MEQ. On the contrary Day et al²⁶ observed in their study that MEQ's failed to measure the aspects of competence over and above those measured by MCQ's.

Competency based medical education is the need of the hour. A balanced assessment format encompassing all the learning domains is essential for the undergraduate curriculum itself. As on date the disparity in the assessment pattern of undergraduate (mainly SAQ, MEQ and LAQ) and post graduate and other high stake examinations (MCQ only) have resulted in students losing their self-confidence and interests in the traditional teaching methods. Hence, this study was conducted to sensitize the undergraduate medical students regarding MCQ pattern of questions being implemented for formative assessments since undergraduate level itself and also to observe the possible potential changes in their learning pattern, performance and acceptability thereby resulting in better performance in the future high stake examinations.

MATERIAL AND METHODS

The students, participating in this study, were oriented to the purpose of the study and were motivated to participate in the study. Subsequently prior to the implementation of the assessment, written informed consent was obtained from each participating student. Those MBBS students who participated in all 3 formative assessments were included in the study. Institute Ethical Clearance was obtained prior to the initiation of the study. The study was conducted in a 6 months' time period. Since this was a formative assessment to estimate learning gain analysis, intention was to include all 150 newly admitted MBBS students of 1st year attending Physiology. 98 students did not attend all 3 formative assessments. Hence they were not

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included in the study.

52 MBBS students of KPC Medical College and Hospital participated in all 3 formative assessments as a part of this non randomized observational study on Formative assessment of the Module of Haematology portion of the Physiology MBBS syllabus who were included as the sample for this study.

3 sets of questionnaire were prepared and validated. Each set of questionnaire comprised of a total of 20 MCQs divided into two sections (Section A and B) of 10 questions of 1 mark each, having a stem, body, four distracters and a key which was hidden. Section A had 10 MCQs more of a recall type and Section B 10 PBQs for testing the critical, analytical and problem solving skills. Total time allotted for the entire test was 30 minutes only. All the students present were subjected to a pre-test before the teaching of the topic and another post-test 2 days after the topic was taught. The two days gap prior to post test was allotted for the students' learning purpose. The topics, in Haematology, selected for the tests, were RBC, WBC and Coagulation.

STATISTICAL ANALYSIS

It was seen that 52 students persistently undertook all the three sets of pre and post tests. Data were analysed quantitatively from the Pre and Post test scores. Absolute and Relative Learning Gains were calculated and statistically computed using the IBM SPSS software. One tail t test, paired t test, correlation coefficient and their significance were also studied using the software.

The various sets of pre and post test questionnaire were compiled and the respective Learning Gains were calculated as follows:

Absolute Learning Gain = Post-Test Score – Pre-Test Score

Relative or Normalized Learning Gain

$$= \frac{\text{Post-test Score} - \text{Pre-test Score}}{10 - \text{Pre-test Score}} \times 100$$

One tail t-test was conducted to analyse the significance of the learning gains. A paired t-test was conducted thereafter to analyse whether the learning gains of the two different formats of questions over the 3 sets were significantly different from each other. The Pearson's Product Moment Correlation Coefficient "R" indicated whether there is any correlation in the learning gain between the two different format of questions of MCQ and PBQ. The significance of the correlation, if any, was also studied.

RESULTS

Table-1 depicts the data of the 1st set of questionnaire. The mean Absolute and mean Relative Learning Gains are 3.58 and 57.23% in case of MCQ with 4 distracters and 2.27 and 31.14% for PBQs. One tail t test showed significant difference in data. Table 2 shows the data of the 2nd set of questionnaire. Here again the one tail t test showed significant variation of all the data at 5% level ($p < 0.05$) with an Absolute and Relative Mean Learning Gains of 3.02 and 61.6% for MCQ with distracter and 2.67 and 45% for PBQs respectively. The third table depicts the data for 3rd set of questionnaire. The mean Absolute and Relative Learning Gain for MCQ with distracters is 4.52 and 61.53% respectively. The same parameters for PBQs are 2.88 and 36.52% respectively. The one tail t test was significant for all data ($p < 0.05$). Table-4 shows a comparison between the MCQs and PBQs for both Absolute and Relative Learning Gains.

Chart 1 illustrates a comparative study between Absolute Learning Gains of MCQ with distracters and PBQs over 3 sets of questions. Chart 2 illustrates similar comparative analysis with Relative Learning Gains of MCQ with distracter and PBQ. Table-5 deals with statistical interpretation of the data. A comparative study between the MCQ with Distracter and PBQ, has been substantiated with statistical evaluation using Paired t test. The Relative Learning Gain of the comparative data showed significance at 5% level ($p < 0.05$) for the entire data. The comparison for Absolute Learning Gain was also significant ($p < 0.05$) for Sets 1 and 3 but was not significant ($p > 0.05$) for Set 2. The relation between the two different formats of question papers were analysed from the Pearson's Product Moment Correlation Coefficient denoted by "R". In sets 1 and 2 for both Absolute and Relative Learning Gains a positive correlation was found. In set 2 the Absolute Learning Gain had a negative correlation compared to the positive correlation of the Relative Learning Gain. However none of the correlation coefficient was found to be statistically significant ($p > 0.05$).

DISCUSSION

In medical curriculum, knowledge of Physiology is usually assessed, in the pre-clinical years. Dagogo²⁷ in his study found that students performed better in Physiology MCQ when compared to LAQ. In this study the Selective Response was compared with the Constructive Response. Studies also indicated that variable question formats, though not identical, often showed some significant correlation.^{13,28} In this study, assessment was tested only with two varied types of the single format i.e. Selective Response Questions, (MCQ with distracters and Problem Based MCQ also called PBQ).

All tests were conducted on all 1st MBBS students who took admission to KPC Medical College for their MBBS Curriculum. In spite of the student strength being 150, we could compute data with only 52 students, reason being sequential admission counselling leading to student dropouts and some absentees. Hence only 52 students could be identified who attended all the pre and post- test sessions consistently and thus they formed the study group to avoid misinterpretation of results.

The Absolute and Relative Learning Gains were calculated from the respective formula and statistically analysed. Absolute Learning Gain indicates the actual gain in the test. On the other hand, Relative Learning Gain indicates the percentage of gain achieved in comparison to what could have been achieved. The figures and graphical representation clearly indicates that students did better in MCQ's rather than the PBQ's with a remarkable improvement in performance in the 3rd set indicative of students getting sensitized to the pattern. A similarity was found in the One tail t test where both Absolute and Relative Learning Gains were statistically significant at 5% level ($p < 0.05$) for all the three sets of tests conducted. This is indicative of the fact that the students performed significantly better in the post test, which supports that the Teaching Learning Process helped the students to perform better leading to development of critical, analytical and problem solving skills. There was a dip in the performance of the 2nd set of questions which might be because of the vastness and variation of the topic (WBC) chosen.

A paired t test was calculated to check the significance of the two different formats of the question paper – the MCQ and the

No. of Students	MCQ				PBQ			
	Pre-Test	Post-Test	Absolute LG	Relative LG	Pre-Test	Post-Test	Absolute LG	Relative LG
1	3	8	5	71.43	2	5	3	37.5
2	3	7	4	57.14	1	5	4	44.44
3	5	8	3	60	3	6	3	42.86
4	6	10	4	100	5	7	2	40
5	4	5	1	16.67	2	3	1	12.5
6	5	9	4	80	0	2	2	20
7	2	8	6	75	2	3	1	12.5
8	5	9	4	80	5	7	2	40
9	3	6	3	42.86	1	4	3	33.33
10	1	8	7	77.78	3	6	3	42.86
11	4	5	1	16.67	0	2	2	20
12	4	7	3	50	4	6	2	33.33
13	4	9	5	83.33	4	7	3	50
14	2	7	5	62.5	4	6	2	33.33
15	5	5	0	0	2	4	2	25
16	4	9	5	83.33	3	6	3	42.86
17	5	7	2	40	2	5	3	37.5
18	5	8	3	60	3	3	0	0
19	5	8	3	60	1	3	2	22.22
20	7	10	3	100	1	3	2	22.22
21	3	6	3	42.86	3	3	0	0
22	2	6	4	50	4	6	2	33.33
23	5	8	3	60	2	6	4	50
24	3	6	3	42.86	4	6	2	33.33
25	7	8	1	33.33	0	2	2	20
26	4	7	3	50	1	4	3	33.33
27	2	10	8	100	3	6	3	42.86
28	4	7	3	50	2	3	1	12.5
29	1	5	4	44.44	2	4	2	25
30	3	9	6	85.71	0	2	2	20
31	5	5	0	0	5	7	2	40
32	2	6	4	50	1	4	3	33.33
33	0	9	9	90	3	6	3	42.86
34	3	4	1	14.26	0	2	2	20
35	6	8	2	50	4	7	3	50
36	2	8	6	75	4	4	0	0
37	4	6	2	33.33	2	4	2	25
38	4	6	2	33.33	3	6	3	42.86
39	4	5	1	16.67	1	1	0	0
40	2	8	6	75	3	7	4	57.14
41	6	8	2	50	4	7	3	50
42	4	7	3	50	3	5	2	28.57
43	5	8	3	60	5	6	1	20
44	4	6	2	33.33	2	5	3	37.5
45	4	9	5	83.33	3	6	3	42.86
46	4	9	5	83.33	2	5	3	37.5
47	4	7	3	50	2	5	3	37.5
48	5	7	2	40	3	6	3	42.86
49	6	9	3	75	3	5	2	28.57
50	4	9	5	83.33	4	7	3	50
51	3	10	7	100	4	4	0	0
52	5	9	4	80	2	6	4	50
MEAN ± SD			3.58±1.944	57.73±0.256			2.269±1.050	31.1±0.15
p value (one tail t test)			p<0.05	p<0.05			p<0.05	p<0.05

Table-1: 1st set

No. of Students	MCQ				PBQ			
	Pre-Test	Post-Test	Absolute LG	Relative LG	Pre-Test	Post-Test	Absolute LG	Relative LG
1	4	9	5	83.33	3	5	2	28.57
2	5	8	3	60	2	5	3	37.5
3	3	7	4	57.14	4	6	2	33.33
4	7	9	2	66.67	3	6	3	42.86
5	6	9	3	75	4	7	3	50
6	4	9	5	83.33	5	7	2	40
7	5	8	3	60	4	6	2	33.33
8	7	10	3	100	5	8	3	60
9	5	9	4	80	6	9	3	75
10	6	10	4	100	5	8	3	60
11	4	8	4	66.67	3	7	4	57.14
12	3	7	4	57.14	5	8	3	60
13	2	5	3	37.5	6	8	2	50
14	5	8	3	60	5	7	2	40
15	8	10	2	100	4	5	1	16.67
16	0	6	6	60	5	5	0	0
17	4	9	5	83.33	7	10	3	100
18	7	9	2	66.67	5	7	2	40
19	5	8	3	60	4	7	3	50
20	6	6	0	0	6	8	2	50
21	5	9	4	80	5	7	2	40
22	3	7	4	57.14	3	5	2	28.57
23	6	8	2	50	2	5	3	37.5
24	5	7	2	40	4	7	3	50
25	5	5	0	0	0	5	5	50
26	6	8	2	50	4	7	3	50
27	4	7	3	50	6	7	1	25
28	5	9	4	80	3	6	3	42.86
29	4	8	4	66.67	5	9	4	80
30	6	8	2	50	4	8	4	66.67
31	4	9	5	83.33	2	5	3	37.5
32	3	7	4	57.14	1	6	5	55.56
33	5	8	3	60	3	6	3	42.86
34	5	9	4	80	4	8	4	66.67
35	6	9	3	75	3	5	2	28.57
36	7	8	2	33.33	6	8	2	50
37	5	9	4	80	8	9	1	50
38	4	8	4	66.67	5	8	3	60
39	6	9	3	75	7	8	1	33.33
40	5	8	3	60	2	5	3	37.5
41	5	7	2	40	3	6	3	42.86
42	7	9	2	66.67	0	4	4	40
43	3	5	2	28.57	2	6	4	50
44	4	6	2	33.33	4	7	3	50
45	2	5	3	37.5	1	4	3	33.33
46	5	7	2	40	4	6	2	33.33
47	6	6	0	0	3	6	3	42.86
48	8	10	2	100	4	7	3	50
49	7	9	2	66.67	5	5	0	0
50	4	8	4	66.67	3	6	3	42.86
51	6	10	4	100	4	7	3	50
52	6	8	2	50	5	8	3	60
MEAN ± SD			3.02± 1.276	61.16±0.238			2.67 ±1.043	45.2±0.171
p value (one tail t test)			p<0.05	p<0.05			p<0.05	p<0.05

Table-2: 2nd set

No. of Students	MCQ				PBQ			
	Pre-Test	Post-Test	Absolute LG	Relative LG	Pre-Test	Post-Test	Absolute LG	Relative LG
1	2	6	4	50	1	2	2	11.11
2	5	9	4	80	1	4	3	33.33
3	3	8	5	71.43	3	7	4	57.14
4	2	7	5	62.5	2	5	3	37.5
5	0	6	6	60	0	3	3	30
6	2	9	7	87.5	2	6	4	50
7	1	7	6	66.67	2	5	3	37.5
8	2	9	7	87.5	1	5	4	44.44
9	3	9	6	85.71	2	6	4	50
10	2	7	5	62.5	2	5	3	37.5
11	1	4	3	33.33	0	2	2	20
12	3	8	5	71.43	1	3	2	22.22
13	2	6	4	50	2	4	2	25
14	3	7	4	57.14	1	3	2	22.22
15	2	6	4	50	2	5	3	37.5
16	3	6	3	42.86	3	6	3	42.86
17	2	6	4	50	0	3	3	30
18	4	9	5	83.33	3	5	2	28.57
19	2	7	5	62.5	2	6	4	50
20	3	7	4	57.15	2	5	3	37.5
21	4	9	5	83.33	1	3	2	22.22
22	2	8	6	75	2	5	3	37.5
23	2	5	3	37.5	3	6	3	42.86
24	2	4	2	25	3	7	4	57.14
25	3	7	4	57.14	2	5	3	37.5
26	4	9	5	83.33	0	3	3	30
27	3	9	6	85.71	1	3	2	22.22
28	4	10	6	100	4	8	4	66.67
29	3	8	5	71.43	3	6	3	42.87
30	2	5	3	37.5	2	5	3	37.5
31	3	8	5	71.43	1	3	2	22.22
32	5	9	4	80	3	7	4	57.14
33	3	8	5	71.43	4	9	5	83.33
34	0	4	4	40	2	6	4	50
35	2	7	5	62.5	1	3	2	22.22
36	3	8	5	71.43	2	5	3	37.5
37	1	3	2	22.22	1	2	1	11.11
38	2	6	4	50	3	6	3	42.86
39	2	7	5	62.5	2	5	3	37.5
40	1	5	4	44.44	3	6	3	42.86
41	1	6	5	55.56	1	4	3	33.33
42	3	7	4	57.14	1	3	2	22.22
43	3	8	5	71.43	2	5	3	37.5
44	2	5	3	37.5	1	3	2	22.22
45	3	9	6	85.71	3	7	4	57.14
46	3	8	5	71.43	2	5	3	37.5
47	2	6	4	50	2	4	2	25
48	2	4	2	25	3	6	3	42.86
49	3	8	5	71.43	1	3	2	22.22
50	2	6	4	50	1	2	1	11.11
51	2	5	3	37.5	2	5	3	37.5
52	4	9	5	83.33	3	6	3	42.86
MEAN ± SD			4.52±1.163	61.52±0.1864			2.88±0.832	36.50±0.143
p value (one tail t test)			p<0.05	p<0.05			p<0.05	p<0.05

Table-3: 3rd SET

PBQ. The role of teaching learning and the interdependency or correlation between the formats was calculated from Pearson's Product Moment Correlation Coefficient. The Relative Learning Gain of the comparative data showed significance at 5% level ($p < 0.05$) for all the data. The comparison for Absolute Learning Gain was also significant ($p < 0.05$) for Sets 1 and 3 but not significant ($p > 0.05$) for Set 2. The probable reason might be that the basic performance may not be up to the mark as depicted by the fall in the Absolute Learning Gain as the topic chosen was vast and students did not have much exposure to details of WBC or Immunity in contrary to first topic RBC and third topic Coagulation. The relation between the two different formats of question paper was analysed from the Pearson's Product Moment Correlation Coefficient denoted by "R". In sets 1 and 2 for both Absolute and Relative Learning Gains, a positive correlation was found. In set 2 the Absolute Learning Gain had a negative correlation compared to the positive correlation of the Relative Learning Gain. However, none of the correlation coefficient was statistically significant ($p > 0.05$). A positive correlation is indicative of the fact that development of the cognitive domain will certainly be reflected equally as a positive gain for both MCQ and PBQ. Again the negative correlation might be for the same reason of improper choice of topic or setting up of difficult distracters, framing of questions, difficulty in understanding or comprehending by the students or short gap between the topics taught and tested. Surprisingly none of the correlation was significant which may be due to the fact that the students were just taught the subject. They were not exposed to Problem Solving or Case Discussions.²⁹ Hence only those who had the inherent interest probably took to the task and solved it correctly. Chances being the more competent student group might have performed poorly in PBQ's due to their ability to read more into the problem than intended. Further, item analysis would have categorised the MCQ and PBQ's on the basis of the difficulty index and distracter index as well as functionality of distracter. Study was also conducted by researchers to bring out an effective assessment method for correct evaluation of the competency of a medical graduate.³⁰

Students' score in each format cannot be correlated with scores in some other formats. Some studies have reported statistically significant correlations between the MCQ's and MEQ's in

continuous Physiology assessment tests.²⁶⁻²⁷

CONCLUSION

In India very few Universities have restructured their curriculum in line with competency based medical education. MBBS students face summative assessments with constructive response type questions during the tenure of medical education. However, MBBS students in high stake exams face MCQ which may prove to be a difficulty to fair well. In this study, a continuous series of assessment on various topics, all MCQ and PBQ based, have sensitized the MBBS students to the selected response format of questions which also contributed in developing critical analysing skills among the students. The test scores were indicative of an average gradual improvement in the learning gains. Therefore there is a need for introduction of MCQ from the very initial stage of medical education.

Further critical analysis indicating a correlation between MCQ and PBQ though not a significant finding, can be justified by lack of exposure of the students to the case or problem solving studies. The aim of introducing MCQ pattern as assessment

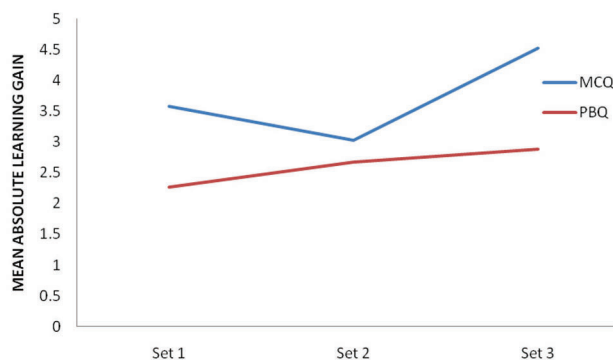


Figure-1: Comparative analysis of mean absolute learning gain of MCQ and PBQ

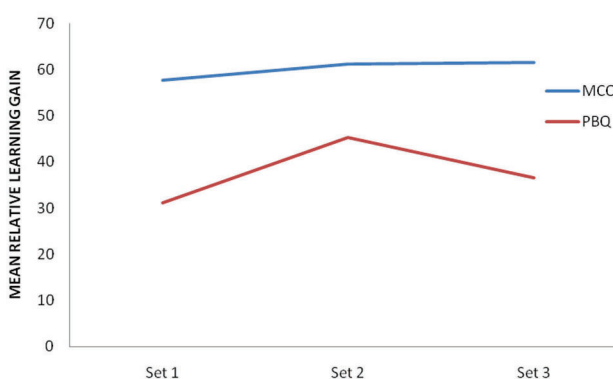


Figure-2: Comparative analysis of mean relative learning gain of MCQ and PBQ

Absolute Learning Gain	Set 1	Set 2	Set 3
MCQ	3.58	3.02	4.52
PBQ	2.27	2.67	2.88
Relative Learning Gain	Set 1	Set 2	Set 3
MCQ	57.73	61.16	61.52
PBQ	31.14	45.24	36.5

Table-4: Comparative study of the mean learning gains

	Set 1		Set 2		Set 3	
	Absolute Learning Gain	Relative Learning Gain	Absolute Learning Gain	Relative Learning Gain	Absolute Learning Gain	Relative Learning Gain
p-value (paired t test)	0.00; $p < 0.05$ Significant	0.00; $p < 0.05$ Significant	$p > 0.05$ Not Significant	0.00; $p < 0.05$ Significant	0.00; $p < 0.05$ Significant	0.00; $p < 0.05$ Significant
Correlation Coefficient	0.381	0.198	-0.157	0.049	0.306	0.256
p-value correlation	$p > 0.05$ Not Significant	$p > 0.05$ Not Significant	$p > 0.05$ Not Significant	$p > 0.05$ Not Significant	$p > 0.05$ Not Significant	$p > 0.05$ Not Significant

Table-5: Statistical evaluation of the learning gains

tool in Physiology has been achieved meeting the objectives of sensitizing the students to MCQ pattern and thereby correlating Teaching Learning with assessment. However a larger sample size and further analysis on the basis of the high and low achievers might contribute in better outcome measures. The same protocol of assessment pattern can be taken up by other pre and para clinical subjects as well, and the data can be computed to enhance further integrated analysis.

In future extended multi-centric, multidisciplinary study can be performed to identify assessment strategies, learning gains, potential outcome measures which would further influence the undergraduate medical curriculum design, educational policies and intervention strategies.

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