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Original Research Article

Correlation of MCQ subtypes with grading of performance among undergraduate students in a preclinical discipline

Jayshri Ghate, Meenakshi Sinha*, Ramanjan Sinha

Department of Physiology, All India Institute of Medical Sciences, Raipur, Chhattisgarh, India

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***Correspondence:**
Dr. Meenakshi Sinha,
E-mail: sinham66@aiimsraipur.edu.in

ABSTRACT

Background: Multiple choice questions (MCQs) remain an important tool for objective assessment in medical students wherein different types of MCQs reflect students' performance towards various aspects of cognitive domain. Thus, all students may not perform with similar ability across all different types of MCQs. In this context, the current study aim to investigate whether performance of medical students in MCQ based assessment relates to the performance in different subtypes of MCQs in Physiology.
Methods: Marks obtained in 65 MCQ during formative assessment by 145 first year MBBS students were segregated into four different types of standard MCQs attempted (i.e. Single Response-SRQ, Multiple Response-MRQ, Reason-Assertion-RAQ and Problem based-PBQ) while students were grouped into High, Medium and Low achievers (HA, MA and LA respectively) in relation to their total score.
Results: Result showed highest scores in SRQ (69.00±11.6%, 57.34±11.12% and 40.11±13.03%) and PBQ (71.04±11.68%, 59.38±15.36% and 42.35±15.72%) but lowest in MRQ (49.16±11.58%, 41.39±12.42% and 30.78±14.10%) and RAQ (48.82±12.48%, 44.17±14.25% and 31.80±13.05%) for HA, MA and LA respectively with significant differences among all groups. However, total MCQ marks were significantly correlated with MRQ and PBQ for HA; with SRQ and MRQ for MA; and SRQ, MRQ and PBQ for LA.
Conclusions: MRQ might have significant influence on the outcome of MCQ based assessment in differentiating between high and medium achievers, whereas both MRQ and PBQ shows potential to differentiate between high and low achieving students. This may be utilized for effective screening in summative assessments or progress of learning in formative assessment.

Keywords: High achiever, Low achiever, Multiple response questions, Reason assertion, Types of MCQ

INTRODUCTION

It is a well-known fact that methods of assessment drives learning and holds utmost important place in medical education.[1] Hence it is very important to use various assessment tools which can test the qualities of a medical student who are going to be professionals. Multiple choice questions (MCQs) based evaluation is one of the commonly used methods of formative assessment of medical students apart from structured short answer questions, long answer questions and practical examination. MCQs are reliable tools and suitable for use due to its obsectivized scoring and ease of administration. But, some even criticized MCQs with the claim that they cannot assess higher order learning and analytical skills.[2] However, a properly constructed MCQ can assess not only cognitive but also affective, as well as psychomotor domain besides having other important features like,

objectivity in assessment, comparability in different settings, wide coverage of subject, and minimization of assessor's bias which make it a very good tool for assessment of the medical students.[3]

In response to this, MCQs are now being constructed with an aim to assess higher cognitive levels like comprehension, application of knowledge and analysis by providing students with information or a scenario to solve a problem.[4-6] Nowadays, people have been using several types of MCQs for evaluation purpose e.g. Single best option, extended matching type, True false type multiple choice question, Assertion-Reason type and multiple-option multiple choice question to test the different domains of learning as per Bloom's Taxonomy.[7-10]

Therefore, it is expected that relative difficulty in terms of solving such questions would put challenge to students on the basis of their intelligentsia and would affect their performance or achievement in examinations. However, only sparse attempts has been made yet to understand how these different sub-types of MCQs relate to the students' performance in assessment and thus definitely needs to be evaluated across a uniform platform. This may be utilized for predictive assessment and screening tests in larger groups over a smaller time frame.

In this context, the current study aim to achieve the aforesaid objectives using various types of such MCQs e.g. Single Response (SRQ), Multiple Response (MRQ), Reason Assertion (RAQ) and Problem Based Questions (PBQ) as evaluation tools for an MCQ based assessment and to assess the relation (if any) in the performance of these four types of MCQs among high, medium and low achieving students, using retrospective data.

METHODS

Study setting

It was a cross sectional study conducted in the Department of Physiology, All India Institute of Medical Sciences (AIIMS) Raipur. The study was duly approved by institution ethical committee. Initially, eighty MCQs of four different types were selected and administered to 145 first year MBBS students during their formative assessment (pre-professional) examinations for the batches 2012-13 and 2013-14.

All the questions represented the core curriculum of first year undergraduate medical physiology comprising of full year syllabus. Time allotted for answering 20 MCQs (comprising of all 4 types) was half an hour i.e. 1.5 min/question. The MCQ answering time was part of 3 hours written paper where Half marks were given for each correct answer and zero marks for wrong answer with no negative marking. Students were required to mark the correct option (i.e. a, b, c, d or e) on the provided answer sheet in this fixed time period.

Thereafter, difficulty index of each question was calculated as a part of item analysis with the help of following formulae: Difficulty Index (P) = h + l / n X 100, where h is the number of students answering the item correctly in the top third high achievers, l is the number of students answering the item correctly in the bottom third of low achievers as per the order of merit based on their scores and n is total number of students in the two groups.[11]

Following this, fifteen MCQs were found unsuitable due to their extreme range of Difficulty Index, as obtained after Item Analysis. Finally, sixty five MCQs with the difficulty index within acceptable range (30-70 %) were included for the present study and students' performance were calculated on the basis of marks obtained in these 65 MCQs only.[12]

Types of MCQs

The types of MCQs were Single Response (n=17), Multiple response (n=18), Reason-Assertion (n=15) and Problem Based Questions (n=15). Single Response MCQ is provided with a stem and list of alternatives which contain single correct response among four distracters. Multiple response type variety has one or more than one correct answers which a student is required to answer as per the instruction format. It is also known as complex multiple-choice, multiple multiple-choice, or type K questions. Reason assertion type has two statements, A and B, for which a student is asked to decide if the statements are correct/wrong and also if both are causally related/not related which he answers from the four given options. In problem based questions, a clinical/real life problem is given and only one of the four alternatives is the correct answer. Instruction sheets are provided to students during examination for solving these MCQs. Table 1 depicts the instruction provided to the students while attempting MCQ examination along with one example of each type of MCQ.

Statistical analysis

The marks obtained in MCQs by all the students were arranged in descending order and were converted into percent score. The minimum total marks obtained by the students were 25% and maximum was 87%. Thereafter, the whole group was divided into three sub-groups i.e. high scorers (>65%), middle scorers (50% to 65%) and low scorers (<50%), on the basis of their total percent marks obtained in MCQ examination as reported by us earlier.[13] These groups were labeled as High, Medium and Low achievers respectively.[14]

The data was analyzed by Statistics' software version 1.7. Single Factor ANOVA with Tukey's post hoc comparisons was done to measure the significance of difference between the marks obtained by high vs. medium and low; and medium vs. low achievers for all four types of MCQs. Pearson's correlation was performed

to test the correlation between the total marks obtained vs. marks obtained in each of the different types of MCQs for all three groups of achievers. A p value of 0.05 or less was considered statistically significant

Table 1: Instructions for attempting MCQ with example of each type.

TYPE of MCQ	Instructions for attempting	Example question
Single response (SRQ)	Each of the questions is followed by four alternatives. Select the best or the most appropriate answer and write in the space provided.	All of the following are true about salivary secretion EXCEPT a) Regulation is by hormonal mechanisms b)pH range is between 6-7 c) Helps in carbohydrate digestion d) Protects teeth from dental carries
Multiple response (MRQ)	For each question, one or more than one alternatives are correct choices and the code is provided below to respond accordingly. Select the most appropriate code and write in the space provided. a. If only 1, 2 and 3 are correct b. If only 1 and 3 are correct c. If only 2 and 4 are correct d. If only 4 is correct e. If all are correct	A lesion in the Reticulospinal tract will produce : 1) flaccid paralysis of distal muscles 2) difficulty in posture maintenance against gravity 3) difficulty in typing a letter 4) spastic paralysis of proximal muscles
Reason-assertion (RAQ)	Each item below consists of two statements marked as (A) and (B) respectively. Please select the code for your response according to the instructions given below and write in the space provided. a. If both (A) and (B) are correct statements and (A) and (B) are causally related. b. If both (A) and (B) are correct statements but (A) and (B) are causally NOT related. c. If (A) is correct and (B) is NOT correct. d. If (A) is NOT correct and (B) is correct. e. If both (A) and (B) are NOT correct.	Assertion: Tm (transport maxima) limited reabsorption implies that below a threshold tubular load, the substance is completely reabsorbed. Reason: All the actively reabsorbed substances in renal tubules exhibit Tm.
Problem based (PBQ)	Read the passage carefully. Select ONE appropriate alternative and write in the space provided.	A COPD patient was admitted to the emergency with an acute attack of breathlessness and dyspnea. His arterial PCO_2 was 50 mmHg. The attending junior doctor put him on 100% O_2 inhalation following which his arterial PO_2 improved. All of the following would be seen in this case EXCEPT. a) Depression of ventilation b) Acute respiratory failure c) Fall in arterial PCO_2 level d) Increased breathlessness

RESULTS

145 1st year MBBS students underwent an MCQ based evaluation during their pre-professional examination for the full course of Physiology where sixty-five MCQs of four types (SRQ, MRQ, RAQ and PBQ) were used as shown in Table 2. On the basis of total marks (%) obtained in the MCQ assessment, the students were divided into three groups of high, middle and low achievers as depicted in Table 3.[14]

Maximum number of students i.e. 61 was found to be in the category of medium achievers with total percent score from 50% to 65% (Table 3). Statistical analysis of the

total % marks obtained in MCQs by all the groups of students revealed that the average performance of high achievers (72.35±5.85%) was significantly higher ($p<0.001$) when compared with middle (55.87±3.88%) and low achievers (40.40±6.36%) as shown in Table 3.

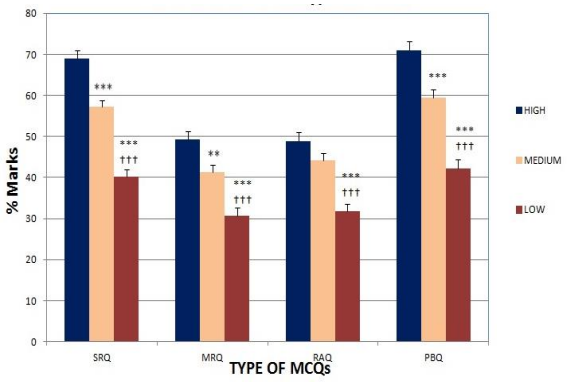
Table 2: Number of different types of MCQs administered.

Type of MCQ	Single Response (SRQ)	Multiple response (MRQ)	Reason-Assertion (RAQ)	Problem based (PBQ)	Total
Number of questions administered	17	18	15	15	65

Table 3: Categorization of achievers in terms of total % marks obtained in MCQs.

	Student Group		
	High achievers (>65%)	Medium achievers (65-50 %)	Low Achievers (<50%)
Number of students(n) Total=145	n=33	n=61	n=51
Total Marks % (Mean±SD)	72.35±5.85	55.87±3.88***	40.40±6.36***/†††

Total marks obtained by High Achievers was significantly greater as compared to Medium and Low Achievers.(*high vs. medium & low achievers & † medium vs low achievers); ***/††† indicates $p\leq0.001$.



A highly significant difference was observed between high vs. medium & low achievers (denoted by *) for all types of MCQs except for RAQ between high vs low achiever, whereas difference between medium vs. low achiever (denoted by †) was highly significant for all types of MCQs; (** $p\leq 0.01$, ***/ ††† $p\leq 0.001$).

Figure 1: % marks (Mean±SE) obtained in different types of MCQ by high, medium and low achievers.

Average marks obtained by all the students were highest in PBQ (71.04±11.68%) and lowest in MRQ (30.78±14.19%). Besides, students of all three groups scored maximum marks in PBQ followed by SRQ, whereas, minimum marks were scored in MRQ and RAQ (Figure 1).

It was also observed that scores obtained in each type of MCQ were significantly different across the different levels of achievers (between high vs medium and low, and medium vs low) except for RAQ marks between high (48.82±12.48%) and medium (44.17±14.25%) achievers (Figure 1).

Correlation of performance in each type of question with total performance: Scores obtained in MRQ bears a significant correlation with the total mean scores of all types of achievers. In addition, the total score was found to be significantly correlated with scores in PBQ for high, with SRQ for medium and with SRQ and PBQ for low achievers. However, no correlation was observed between RAQ and total scores among any of the groups of achievers (Table 4).

Table 4: Correlations of total marks obtained with various types of MCQ across different achiever groups.

Pearson's Correlation	High Achiever	Middle Achiever	Low Achiever
Total vs SRQ	-0.146 (NS)	0.351(**)	0.405(**)
Total vs MRQ	0.337(*)	0.353(**)	0.312(*)
Total vs RAQ	0.173(NS)	0.206(NS)	0.029(NS)
Total vs PBQ	0.363(*)	0.065(NS)	0.531(***)

Total marks obtained by High Achievers were significantly correlated with MRQ and PBQ, whereas SRQ & MRQ was significantly correlated in middle achiever. All the types of MCQs except RAQ showed significant correlation with total marks in low achiever (expressed as r value with significance in parentheses); (*$p\leq0.01$, **$p\leq0.01$, ***$p\leq0.001$, NS:not significant).

DISCUSSION

It is observed that the performance of high achievers was better in all types of questions when compared with medium and low achievers (Figure 1). Highest score was obtained in PBQ and SRQ type of MCQs across all examinees which points toward the vulnerability of this instrument towards guessing, i.e. probability of marking correct alternative upto 25% with four choices as both of them are single response questions and also as there was no negative markings for wrong answers.[15]

Earlier reports using MCQs in paraclinical subjects as well as in preclinical summative tests have also indicated on similar lines regarding roles of guesswork by the students.[8,16] As was pointed out earlier that this guesswork in examination is more common among low performers which might be true in our case also.[17] In this context, it may also be emphasized that all the MCQs used for interpretation of data had difficulty index within acceptable range of 30-70% and therefore, may be considered to offer uniformity in terms of quality of questions administered to all the students.

On the other hand, these examinees obtained lowest scores in MRQ and RAQ thereby putting these as the toughest variant of MCQs attempted. In an earlier study done by Agu et al where widely different tools of assessment (i.e., MCQ, essay type, practical or viva) were used, better performance was reported by the good students irrespective of type of examinations as compared to weak students.[18] However, present study with three-tier stratification of achievers (i.e. high, medium and low) in a MCQ based assessment using four different subtypes of MCQs (i.e. SRQ, MRQ, RAQ and PBQ), further revealed that performance of high and middle achievers was uniformly better in all types of MCQs administered (Figure 1), which are supposed to test the different learning domains.

However, on further analysis, it was observed, that performance of middle achievers was significantly low as compared to high achievers for all subtypes of MCQs except RAQ (Figure 1). Hence RAQ is a type of MCQ which might help to discriminate the low achievers from rest of the performers. As per format, the RAQ has two statements and student has to determine whether statements are true or not, and whether the two statements are causally related. Thus it has complicated characteristics of multiple choice as well as true and false type question, requiring higher level of learning.[19] Also, it has been reported that RAQ is a good predictor of student performance through essay type evaluation, as well as, an indicator of deeper learning.[9] Therefore, it appears from our study that high as well as middle achievers have higher intellectual ability and are able to solve the complicated MCQs like RAQ and hence RAQ can be a tool for differentiating these groups of students from low achievers. Besides, construction of RAQ is also known to save time for the teachers as it does not require writing of plausible distracters which is time consuming and most difficult part of preparing MCQs.[20] However, absence of correlation for RAQ with the total marks in all the achiever groups in our study point towards the fact that RAQ was one of the most trickiest and difficult tool of evaluation, as also evident from the marks scored in this type of MCQ by all the achievers. Students, irrespective of their intelligentsia level, seem to have made maximum mistakes and guesswork while attempting RAQ which might be the reason for absence of any correlation with their total performance.

Significant correlation of total marks with marks obtained only in MRQ type of MCQ in all students indicate MRQ as the most reliable indicator / predictor of performance in MCQs across all groups. It may be envisaged that MRQ is mainly used for assessing the ‘synthesis’ and ‘evaluation’ power of the student. However, choice of answer and its combinations may guide the thinking process of the student.[21] Thus, it has limitations of all-or-none scoring with the multiple-response variety and also providing clues that may help students with only partial knowledge to guess the correct combination of alternatives.[10]

Therefore, MRQ type of MCQ may not be good tool for detecting critical thinking skills of the student though it might help in differentiating the high achievers from average students. This is in agreement with earlier reports on MRQs i.e. type K MCQs, stating its reliability and ability to test higher cognitive abilities as compared to other formats.[6] On the other hand, significant correlation of SRQ score with total MCQ marks obtained by medium and low achiever, and also PBQ by low achiever students might indicate these tools being more reliable indicator / predictor of performance in average and below average students as compared to other types of MCQs.

It has been widely reported that MCQs, if properly constructed, not only addresses the higher cognitive ability of students as per Bloom’s taxonomy with ability to cover more content reliably but can also discriminate between high and low achievers.[22,23] Therefore, a wise combination of such MCQ tools during formative internal assessments might help in early recognition of poor performers (average or low students) and adopting suitable measures e.g. special classes/tutorials for improving their performance. This is particularly important in an MCQ based assessment system, which has the potential to screen large group of candidates in a short period of time with very less manpower involvement.[24]

CONCLUSION

Thus, it may be concluded that RAQ can be a useful tool for screening tests where low performers are to be rejected e.g. screening test for appointments in services, admission to a course etc. Further, MRQ can be used to assess midterm learning patterns in a course e.g. during

formative assessments set-up in a short duration examination format with a few number of MCQs.

However, further studies need to be carried out in this regard in a more uniform set-up involving larger number of each type of MCQs attempted by more examinees to ascertain the reliability and validity of application of these instruments of assessment.

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