

“MOTeL - Multiple Choice Questions Based Orthopaedic Teaching Learning”: A Pilot Study on Formative Assessment Tool in Orthopaedics from Tertiary Care Centre in North East India

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Abstract

The aims and objectives of the study was to assess the perceptions of 50 medical undergraduate students of final year MBBS enrolled at a tertiary teaching medical institution in India about the use of multiple choice questions as the assessment method

for formative assessment in the near future after orthopaedic teaching classes as per orthopaedic curriculum . After obtaining feedback from all the students, it was concluded that multiple choice questions can be used for formative assessment in orthopaedic curriculum on a regular basis.

Aim: To analyses students' perception toward FA in the form of multiple choice questions pertaining to the topic covered in the orthopaedic lecture as per curriculum.

Objectives: To evaluate the ability to apply the knowledge imparted in previous lectures in Orthopaedics MCQ based formative assessment.

Keywords: formative assessment; MCQ; Blooms taxonomy; Millers pyramid; Orthopaedics; medical education; medical undergraduates

Introduction

Musculoskeletal disorders (MSDs) are a significant public health problem throughout the world. There is an increasing burden of musculoskeletal diseases across the societies due to increasing population and life expectancy. It requires future doctors should be well trained and competent in this field. It becomes important for the medical institutions to strengthen undergraduate orthopaedic education to rectify the current deficiency in the services which will eventually translate into better patient care in the days to come. Moreover, in India, the mortality due to polytrauma after road traffic injuries is high and there is a need to train medical and paramedical personnel. Thus MCQ based assessment in Orthopaedic undergraduate medical education can help in circumventing the deficiency in training required in present day scenario for serving our increasing demand of qualified doctors in the society in order to lessen the burden of fundamental orthopaedic care required. Moreover, medical school education has been reported to be inadequate especially in musculoskeletal medicine due to ever increasing medical student and teacher ratio. Also, the confidence, communication and cognitive aspects have been found to be inadequate amongst the undergraduates in orthopaedics as a general perception of teachers across the world, so it is quite imperative to look for alternative methods of assessment to fulfil the requirements as mentioned.

The aim of this study was to evaluate the impact on knowledge and skills through the feedback based on perception of the participants to the orthopaedic topics covered in classes through MCQ based formative assessment.

Formative testing which is often referred to as test-enhanced learning has been found to be the most effective way in improving learning and retention of content across educational contexts [1–3] including medical education [4, 5]. It is unclear whether current post-assessment feedback for multiple choice question (MCQ) tests improves transfer to finding solutions to novel problems. Truly effective feedback should also act as ‘feed forward’ to enable students to extend and apply their knowledge to new problems [6], i.e., to stimulate transfer of learning. To promote transfer, more extensive and purposeful feedback may be necessary. Transfer occurs when conceptual knowledge structures are elaborated to facilitate a learner’s understanding of the underlying deep structure of a problem or the learning material [7, 8].

In order to ensure a strong knowledge base of Trauma & Orthopaedics in medical students, it becomes for medical students who go on to become GPs (General practitioners) have sufficient knowledge to manage patients in the primary setting and make appropriate referral for specialist input. The current medical curriculum lays lot of emphasis on continuous assessment of the students’ performance as compared to the traditional philosophy of summative assessment at the end of the educational program. Moreover, It has been seen that all too often, learning is driven by assessment, serving as the dominant motivator.

Due to time frame given for any educational program students need to gain maximum meaningful knowledge in the short span of time available. Formative assessment (FA) is an intrinsic part of the ongoing teaching-learning process. Wherever possible, therefore, assessment should have some formative component. The immediate feedback given in FA, informs learners of their present state of learning and provides opportunity to modify learning during the learning process (Jain et al., 2012).[9] Also, it helps in detection of learning difficulties which can be corrected by counselling or modifying learning methods and activities with all its added potential to give opportunity to the teachers to improve the weak areas in students learning. [10]

Medical education endeavours to impart holistic training and it encompasses five levels of Bloom’s classification at all stages of educational teaching-learning program. Due to vastness of syllabus and non availability of any one proven method to impart this knowledge, there is a need to determine the most acceptable and practicable method to assist trainers while they engage with their students for a topic of instruction.

Miller introduced a conceptual framework of different aspects of medical competence. [11] These are “knows” (factual knowledge) “knows how” (analysis, application, and interpretation of knowledge), “shows how” (actual application and practical demonstra-

tion in a simulated situation) and “does” (performs in real situations), which are arranged as various layers of a pyramid known as the “Millers pyramid”.

Developmental progression for knowledge has been described in Blooms taxonomy (BT).[12] By designing an assessment applying BT, we can drive deeper learning. [13]

Considering these basic components in mind and the current need for strengthening the medical education in Orthopaedics and trauma, a study on MOTeL i.e. Multiple Choice Questions based Orthopaedic Teaching Learning is conceptualized to evaluate the outcome and make subsequent recommendations for the same.

A good educational activity must be supported by an equally purposeful high quality examination to complete the objectives of a curriculum. Every teaching program depends highly upon the alignment of the assessment with the objectives of the curriculum.

In 1990, George Miller published an article entitled “The Assessment of Clinical Skills, Competence and Performance.” In the original article, Miller stated that “no single assessment method can provide all the data required for judgment of anything so complex as the delivery of professional services by a successful physician.” As with any assessment instrument, MCQ tests do have specific limitations and disadvantages. Yet, if well- constructed and peer reviewed, MCQ tests can meet important educational standards.

Good quality MCQs can test more than the mere recall of knowledge. Benefits of automated marking and a potentially high reliability at low costs make MCQs a viable option [12]. Although guidelines for developing adequate MCQ items are available, the construction of good MCQ tests remains a challenge.

Materials and Methods

A prospective study was conducted after getting the ethical clearance from the Institute Ethical Committee (IEC) at North Eastern Indira Gandhi Regional Institute of Health and Medical sciences (NEIGRIHMS), Shillong (No. NEIGR/IEC/M6/F5/2022) to assess the impact of Multiple Choice Questions based Orthopaedic Teaching Learning “MOTeL” - based on the BT as a tool for FA among 50 MBBS students of 7th semester MBBS attending Orthopaedics curriculum.

To create a friendly environment, students were informed that the participation was voluntary in nature and were assured that their performance in the test will be confidential and would not matter or count in any way toward their course assessment. Students were reassured that they were not expected to perform beyond their ability as per the extent to which the topic got covered by the teacher in the lecture.

4 Lectures were taken in 4 separate classes on the topics in orthopaedics as per departmental schedule. Blueprint of MCQs was formed. Format for MCQs was based on the single best response with 4 options. All MCQs were having single stem with four options including, one being correct answer and other three incorrect alternatives (distracter). MCQs were peer reviewed by the fellow faculty members to ensure the different domains are included and that the level of difficulty is acceptable as per the orthopaedic curriculum. Checklist of the answer key was prepared. Candidate instructions were concise and clear to choose only one option. Students in the subsequent class were given 10 MCQs based on five specific learning objectives and evaluation of each of the correct choices was done after the test. The scores obtained by the students were informed to them but it was made clear that these scores would not be included for assessment. All levels of cognition domain were assessed in each orthopaedic topic with distribution of the MCQ's as follows: 5 questions in level 1 (recall of facts), 2 question in level 2 (interpretation of facts), 1 question in level 3 (problem solving abilities), 1 question in level 4 (application), and 1 question in

level 5 (application and synthesis). Teacher discussed the correctness or mistakes after the

evaluation of the test papers in the subsequent class. The concept of micro-teaching was

adopted while discussion was undertaken with regard to the correctness of the questions used in assessment, so that ultimate aim of achieving proper understanding of the subject topic could have been ensured and thus trying to reduce the bias in relation to the efficacy of MCQs in formative assessment.

A questionnaire based student feedback was obtained subsequently on the entire exercise. The total questionnaire feedback received were 164 after the end of 4 classes. All the students were given appropriate instructions and adequate time to fill in the perception questionnaire which has 10 items statements as per format given. At the bottom of feedback form "open ended comments" section was given so that everyone can freely express their opinion about the study.

Students were given the option whether to write or not to write their names and roll numbers. Feedback responses were then evaluated based on their changed perception on each of the items after the MOTeL. Each of the 10 items will be recorded based on 3--point Likert scale namely, agree, neutral, and disagree to assess the impact of FA and using MCQ as its tool on various aspects of learning.

Statistical Analysis

Data was presented as frequency percentage.

Questionnaire

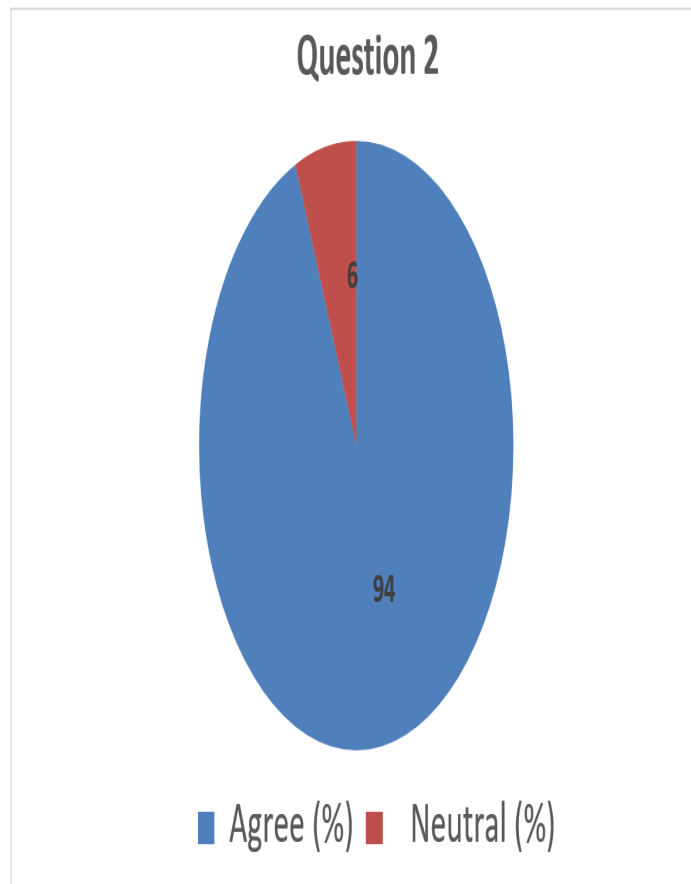
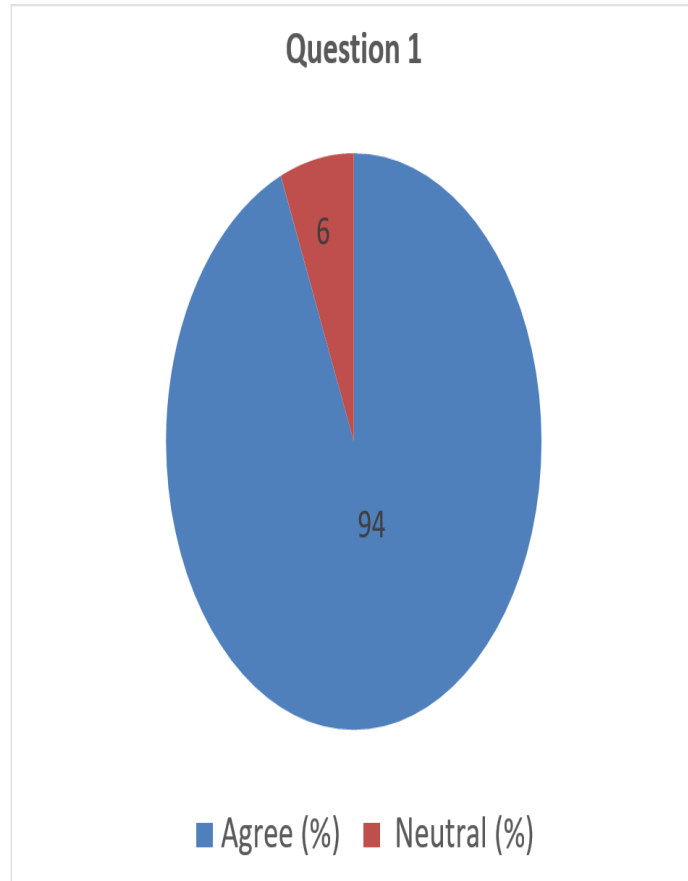
S.No	Items	agree	neutral	Disagree
1.	Promotes my theoretical knowledge			
2.	Creating interest for self- directed learning			
3.	Motivation to listen to class effectively			
4.	Help in better understanding of the lecture being taken			
5.	Continuation of these tests in future classes			
6.	Help to score better in internal exams			
7.	Shows me gaps in my education			
8.	Gives me feedback on my performance level			
9.	Enhances my problem-solving and decision-making abilities			
10.	Suggestions (if any)			

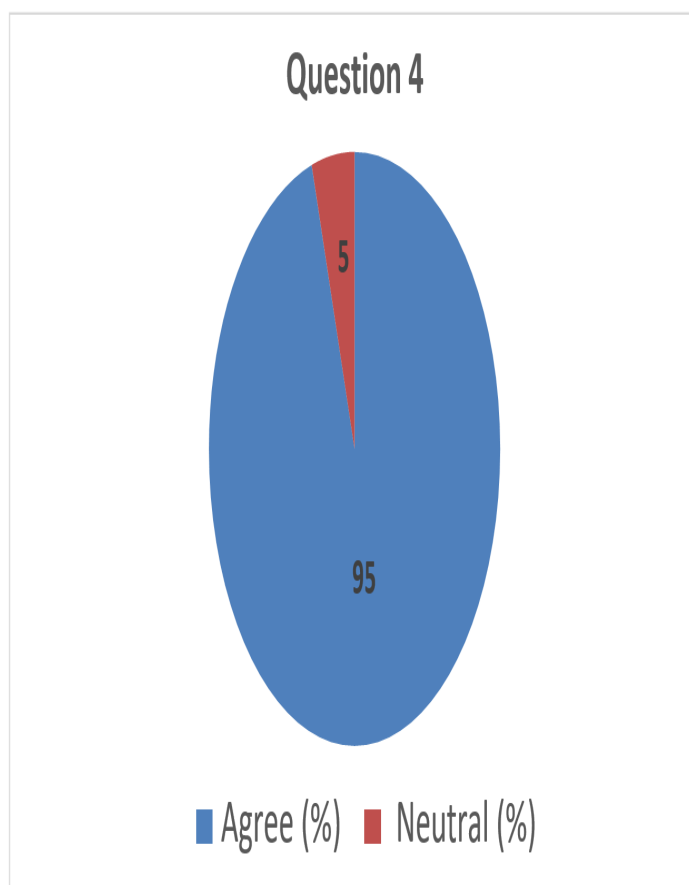
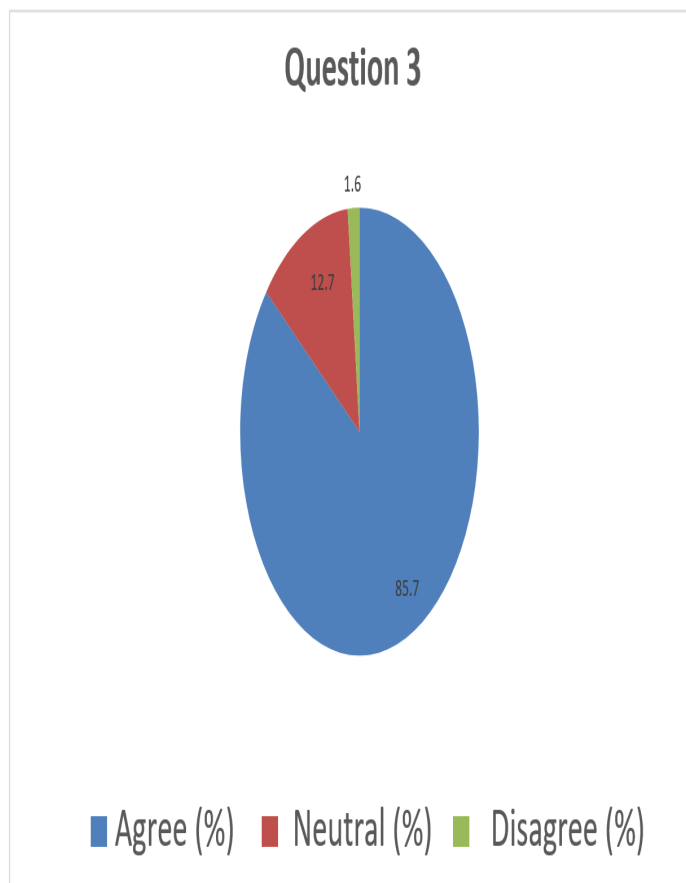
Moreover, demographic data on gender, age will also be taken into consideration during analysis of the results.

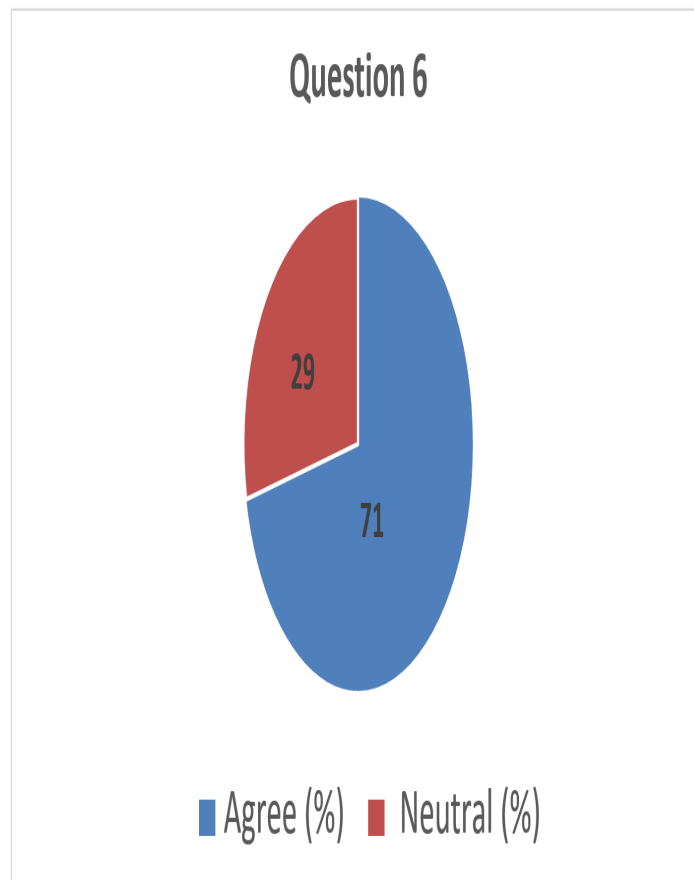
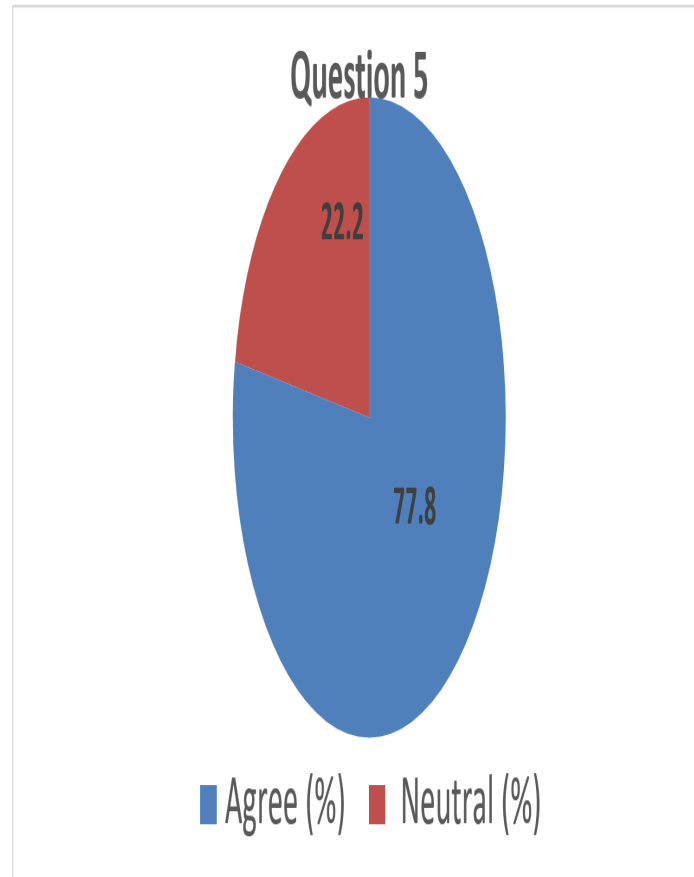
Results

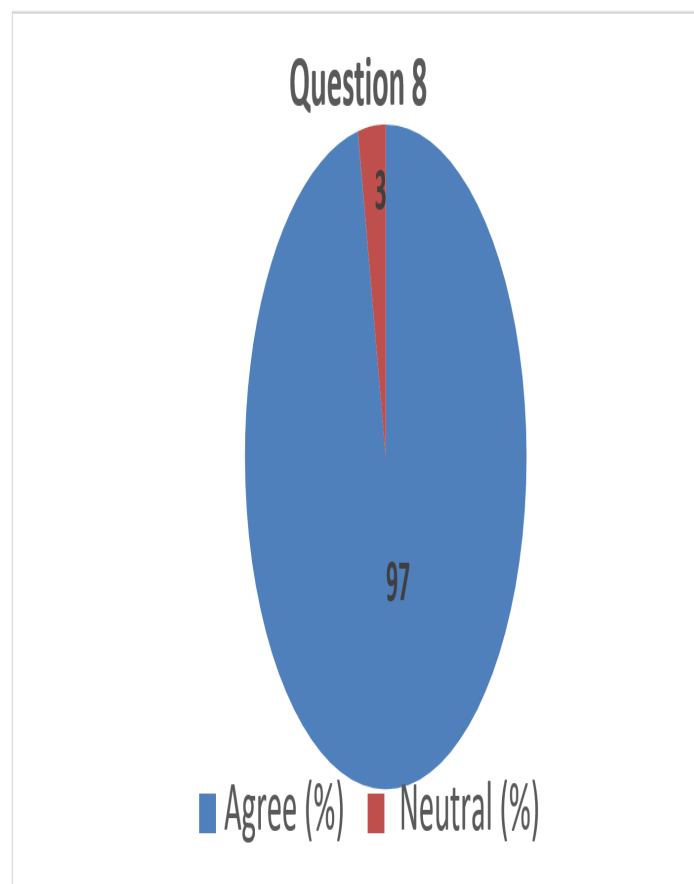
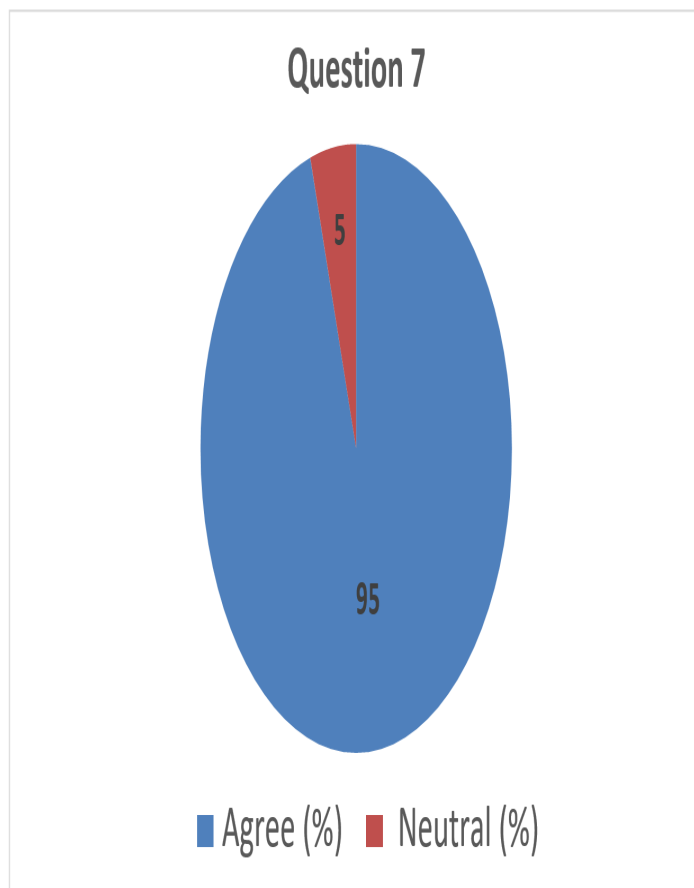
	Q-1	Q-2	Q-3	Q-4	Q-5	Q-6	Q-7	Q-8	Q-9
Agree (%)	94	94	85.7	95	77.8	71	95	97	87
Neutral (%)	6	6	12.7	5	22.2	29	5	3	13
Disagree (%)	0	0	1.6	0	0	0	0	0	0
Total	100	100	100	100	100	100	100	100	100

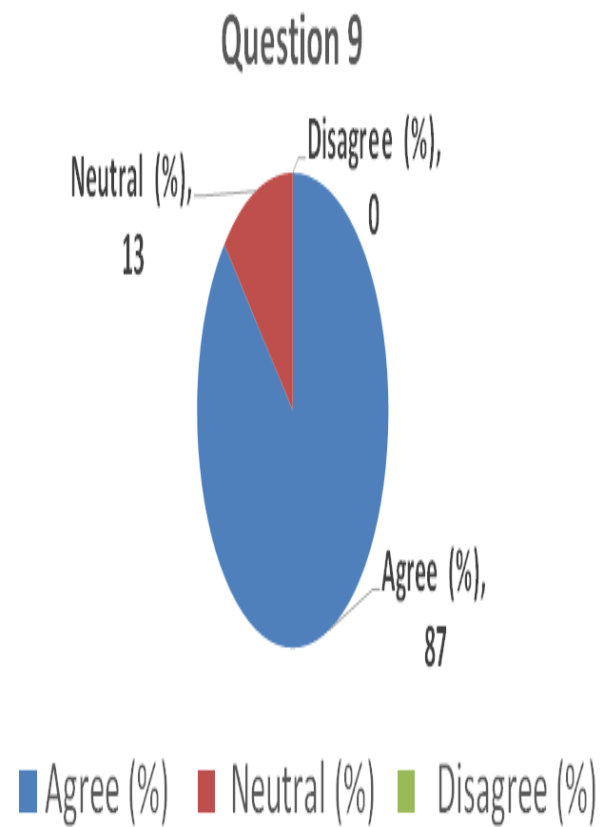
Table 1: Percentage response to Q1-9





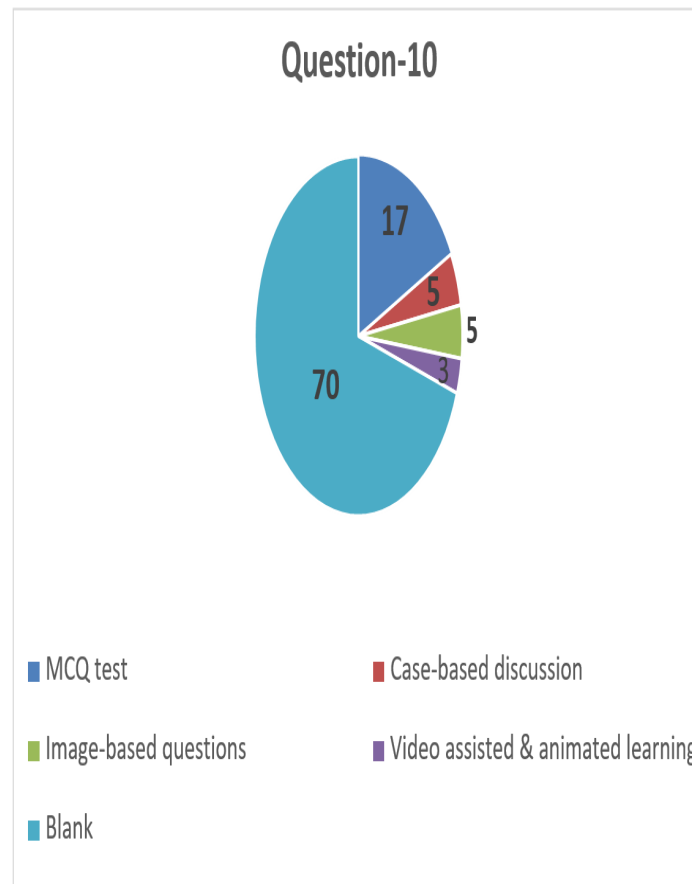






Response	Percentage
MCQ test	17
Case-based discussion	5
Image-based discussion	5
Video assisted & animated learning	3
Blank	70
Total	100

Table 2: Suggestions by students



94% students felt that it 'Promotes theoretical knowledge'; 94% agreed on 'Creating interest for self-directed learning'; 85.7% believed its 'Motivational effect to listen to class effectively';

95% showed that it 'Helped in better understanding of the lecture being taken'; 71% agreed on its 'Helping to score better in internal exam'; 95% agreed on that it 'Showed gaps in their education'; 77.8% wanted 'Continuation of these tests in future classes'; 97% agreed on the fact that it 'Gives feedback on performance level' and 87% believed that it 'Enhances problem-solving and decision-making abilities'. Student's also suggested inclusion of case based, image based and video assisted and animated learning and assessment strategies alongside MCQ's.

This study has shown a strong positive perception towards MCQs to be considered for formative assessment by maximum students. Moreover, an instant assessment of the topic with timely feedback helps in further enhancing student's participation and interest in the class.

Assessment task should ensure transparency, relevance, fairness with meaningful and timely feedback as far as possible. Students as important stakeholders should actively seek information and feedback to support their learning. Educators need to utilise the assessment framework effectively in the development of assessment tasks in order to encourage learning and keep students engaged. MCQ's is a good method for addressing these issues.

Discussion

Bloom's taxonomy is frequently used to describe educational objectives [14, 15] based on a hierarchy of thinking skills (remember, understand, apply, analyze, evaluate, create) that has become a framework for writing questions for assessment in education. Faculty may attempt to write questions to target a specific level of the taxonomy [16], but writing questions that target higher levels of

the taxonomy can be challenging [17-19]. For example, faculty in one study approached MCQ writing at lower and higher-order thinking levels with the intention of testing clinical reasoning skills and information recall, but rewriting was necessary to achieve a balance between question difficulty and Assessing lower or higher order educational objectives. [20]

Multiple choice questions are most familiar as the widely applicable and valuable type of objective test. MCQ can be presented in various format. Commonly used formats are 'one correct answer', 'single or one best answer (SBA/OBA)', 'true or false' and 'multiple true or false', 'matching' and the 'extended matching questions or items (EMQ/ EMI)' and 'case or problem', 'reason-assertion' or 'relationship analysis' format. Buck Walters' Taxonomy describes learning at three levels. According to this Level I is Recall of information, Level II is Comprehension and application and Level III is Problem solving ability which involves analysis, evaluation and creation. MCQ based test has the potential to test all the competencies if executed well. Myth which is wrongly propagated with regard to the ability of the MCQ to test higher order thinking can be dispensed with by a more correct declaration, which would be that MCQs measuring higher ordered thinking are rarely constructed. Importantly, they can be managed in a relatively short period of time and marked by a machine which makes the examination standardized (Epstein, 2007). [21]

To establish usefulness of a particular assessment format, the following five criteria should be considered which are reliability, validity, influence on future thinking and practice, suitability to learners and teachers and expenses (to the individual student and institution) (Vleuten, 1996).[22]

Multiple-choice questions in the assessment of Well-formulated MCQs assess cognitive, affective and psychomotoric domains and are preferred over other methods because they ensure objective assessment, minimal effect of the examiner's bias, comparability and cover a wide range of subjects [23]. Context rich MCQs encourage complex cognitive clinical thinking, while context poor or context free questions mainly test declarative knowledge (facts, "what" information), which involves pure recall of isolated pieces of information such as definitions or terminologies. In contrast, procedural knowledge ("why" and "how" information) requires different skills: Students are encouraged to understand concepts and to gather information from various disciplines in order to apply their knowledge in a clinically-oriented context. Remarkably, prior clinical experience has been suggested to be a strong factor influencing students' performance in procedural knowledge tasks. [24, 25]

In undergraduate medical education, a well-constructed MCQ can easily assess a student's ability to apply, evaluate and judge medical education knowledge (Vanderbilt, Feldman, & Wood, 2013). [26] Nevertheless, writing MCQs capable of assessing higher ordered thinking are challenging (Bridge, Musial, Frank, Thomas, & Sawilowsky, 2003) [27] but can be developed by following certain guidelines, especially ensuring that item writers are competent in their fields (Haladyna, & Downing, 2006)[28]. Scully (2017) [29] invalidated the perception that MCQs can only assess lower ordered thinking.

Fundamental musculoskeletal knowledge is essential to clinical practice. Primary care physicians have been found to be deficient in orthopedic knowledge and skills. [30, 31] Orthopaedic surgeons currently provide only 6% of musculoskeletal care in many developed countries.[32] Good knowledge of the basics in musculoskeletal disorders is therefore essential for all medical school graduates. Hence, there is urgent need to seriously look into the component of assessment that too formative during the curriculum phase, especially in Orthopaedics.

The purpose of assessment is not simply to assess a student on preset criteria and make a decision but also to facilitate his learning through a continuous process of feedback and at the same time provide him/her the opportunity to improve which requires a shift of focus from summative assessment to continuous formative assessment.[33]

Formative assessment occurs when educators feed information back to student in a "low stakes" manner that enables the student to learn better and engage in a self-reflective process regarding the feedback. [34, 35] Its purpose is to provide both feedback on performance and suggestions for improvement. [36, 37] Such an assessment can be provided using a wide range of methods. Miller aptly mentioned that "changing curricula or instructional methods without changing examinations will achieve nothing!"

&“Changing the examination system without changing the curriculum had a huge impact upon the nature of learning”.

The advantages of multiple-choice tests to be found in the literature (eg Epstein et al, 2002; Higgins & Tatham, 2003; Kuechler & Simkin, 2003) [38, 39, 40] include that they can test knowledge quickly within large groups, provide quick feedback and analysed with regard to difficulty and discrimination. For a distracter (wrong option) to be useful, it should represent a common misconception among students about the correct answer. Writing plausible distracters is time consuming and the most difficult part of preparing MCQs.

A well structured polar question can acknowledge higher order diagnostic logical thinking and knowledge, evaluating the examinee's ability to apprehend, judge, and act based on medical information. The consideration behind the formative assessment is because the personal feedback from the tutors or facilitators to the students is as good as assessment and effective feedback can be a tremendous help in building life-long learning. [41, 42]

Well-constructed MCQs form an important tool to reinforce difficult concepts since it involves analysis of each of the choices and step-wise elimination of unacceptable possibilities.[43]. Therefore, when MCQs are discussed during or after a lecture as part of instruction, the students get a chance to not only revise what has been taught but also to process the information in the given context which may have a better recall in future.

Singh et al. have reported that FA has a potential to promote deeper learning by using it for day to day observation of the student [44, 45]. Belghi et al. proposed MCQs for use in assessment of different levels in the intellectual process. For knowledge, concepts, application of knowledge (“knows” and “knows how” of Millers conceptual pyramid for clinical competence) context-based multiple choice questions (MCQs) are appropriate [40]

The MCQ assessment was easy to administer and was not time consuming either for the organiser or the participants. It is well established that use of MCQs is a good and reliable method of testing that correlates well with overall competence and performance [46]. One study found MCQ as a more objective assesment which correlated more to OSPE (short essay tests) [47]. Although primarily employed for assessment, the direct role of MCQ-assisted teaching learning (MATeL) may be explored among teachers and students as an aid to learning [48]

In a study done by Singh A at Bareilly [49], MCQs came out as best assessment tool so it is a good sign of improvement in various competencies and various other studies also concluded that multiple-choice questions (MCQs) test the attitudes, skills, knowledge, and competency in medical school. Rai etal [50] used MCQ as formative assessment tool with vertical integration involving osteology and anatomy and found it useful.

No studies are available with regard to the MCQ usage in orthopaedic teaching learning as a regular practice. Our study does show this potential for future assessment methodology in orthopaedics in India and rest of the world. Our study has clearly helped in highlighting the usefulness of incorporating MCQs for formative assessment, to fulfil the concept of competency based medical education, while considering all the domains of learning as per Bloom's taxonomy (95 % students). It has shown a strong positive perception towards MCQs to be considered for formative assessment on a regular basis by maximum students (87% students). Moreover, an instant assessment of the topic with timely feedback helps in further enhancing student's participation and interest in the class and which forms the main ethos of any educational activity (97% students).

Conclusion

Availability of an objective assessment tool for orthopaedic skills will systemize the delivery and evaluation of these skills in our setting. Further the experience gained through this study will be used to develop objective assessment tools to evaluate the skills in other medical disciplines. MCQs designed as an assessment tool in the present study served three purposes: i.e. ‘Set induction’ to

the lecture; Keeping the students alert by orienting them to the topic as a whole and 'Summary with learning feedback' at the end of the lecture. Positive feedback given by the students regarding the entire set of lectures was highly encouraging and such feedback creates interest among teachers to improve and also towards more interactive and effective teaching- learning sessions. This will ensure in covering the orthopaedic curriculum holistically starting from induction to teaching, assessment and feedback. Pre-test and Post-test MCQs can be used as one of the means of evaluating the effectiveness of lecture. Feedback from students can not only evaluate the lecture effectiveness, but also bridge the gap by teacher- student interaction and help the teacher to improve. A well-structured MCQ has the capacity to assess higher ordered thinking and because of many other advantages that this format offers. Multiple choice questions should be considered as a preferable choice in undergraduate medical education as literature shows that different levels of Bloom's taxonomy can be assessed by this assessment format and its use for assessing only lower ordered thinking i.e. recall of knowledge, is not very convincing. Through this work, we hope to better understand the relationship between frameworks for learning and their practical applicability to assessment of said learning. Faculties should be encouraged to invest in training in constructing good MCQs. Constructing good MCQs, emphasis should be given that, the stem is meaningful and present a definite problem, it contains only relevant material and avoid negativity. It should be ensuring that, all options present as plausible, clear and concise, mutually exclusive, logical in order, free from clues and avoid 'all of the above' and 'none of the above'. Efforts must be made to prepare and use of test blueprint as a guide to construct good MCQs. In order to construct high quality MCQs, institutions must emphasize on faculty development programs in this regard.

Thus by all the positive feedback from the students we concluded that MCQs can be used for formative assessment in the near future and further its scope can be extended to be used for summative assessment too. The teaching faculty gain experience in framing MCQs at various levels of cognition using BT. Further, these tests might have increased the responsibility of a teacher in taking the lecture more effectively. However, there were disadvantages such as time constraint for constructing good test questions for each class. It is the key to develop assessment tasks that fulfil the framework for good assessment. This includes both individual assessments and systems assessment. "We cannot define the attributes of a good question paper unless we define for whom it is going to be administered, and how it is going about testing what it intends to test (anonymous quote)" and also as aptly put by Moorthy- "Without objective, valid, and reliable assessment training programmes cannot ensure the learning of skill, tackle deficiencies in training, and implement remedial measures". [51]

Limitation of Our Study

We could not expand the scope of our research to all topics of orthopaedics. It requires a lot of time to write good questions and requires even more time to write good distracters. While the Likert scale can reflect the level of effectiveness of each component of the programme, it may not be able to establish cause and effect, as it would not be able to reflect the actual factors that contributed to the success of the different components of the programme. Our study does not calculate discrimination and difficulty indices as is generally recommended for MCQs. Our Study is a very small scale exploratory effort that is trying to identify the standard/faults/possibilities of improvements at undergraduate level. In this study the skills were not tested on live patients which when supplemented with MCQ's can ensure predictable performance in real life situations. A single rater assessed all the subjects, hence inter-rater reliability could not be assessed.

Conflicts of Interest

None

Source of Funding

None

References

1. Al-Rukban MO (2006) Guidelines for the construction of multiple choice questions tests. *J Family Community Med.* 3: 125-33. PMID: PMC3410060.
2. Salam A, Rahim AFA, Aziz RA, Fakir NMRM, Jaafar R (2005) Assessment of the students: tools used in Universiti Sains Malaysia. *Bangladesh Medical Journal* 34: 11-3. DOI: 10.31344/ijhhs.v4i2.180
3. Menon PSN, Multiple choice question construction (1995) In: Sood R, Paul VK, Sahni P, Mittal S, Kharbanda OP, Adkoli BV, Verma K, Nayar U (Eds.). *Assessment in medical education. Trends and tools.* K L Wig Centre for medical education and technology. All India Institute of Medical Sciences, New Delhi-India. SEARO WHO project WR/IND HRH 001/LCS.
4. Larsen DP (2013) When I say. test-enhanced learning. *Med Educ.* 47: 961. PMID: 24016165.
5. Larsen DP (2018) Planning education for long-term retention: the cognitive science and implementation of retrieval practice. *Semin Neurol.* 38: 449-56. PMID: 30125899.
6. Sood R, Singh T (2012) Assessment in medical education: Evolving perspectives and contemporary trends. *The National Medical Journal of India* 2012; 25: 357-64. PMID: 23998869.
7. Eva KW, Neville AJ, Norman GR (1998) Exploring the etiology of content specificity: factors influencing analogical transfer and problemsolving. *Acad Med* 73:S1-S5. doi: 10.1097/00001888-199810000-00028. PMID: 9795635.
8. Kulasegaram K, Min C, Howey E, et al. (2015) The mediating effect of context variation in mixed practice for transfer of basic science. *Adv Health Sci Educ Theory Pract.* 20: 953-68. doi: 10.1007/s10459-014-9574-9. Epub 2014 Dec 12. PMID: 25524224.
9. Fowler PJ, Regan WD (1978) The patient with symptomatic chronic anterior cruciate ligament insufficiency: Results of minimal arthroscopic surgery and rehabilitation. *Am J Sports Med.* 15: 321-5. doi: 10.1177/036354658701500405. PMID: 3661812.
10. Ahern MJ, Soden M, Schultz D, Clark M (1991) The musculoskeletal examination: A neglected clinical skill. *Aust New Z J Med.* 21: 303-6. doi: 10.1111/j.1445-5994.1991.tb04694.x. PMID: 1953507.
11. Karpman RR (2001) Musculoskeletal disease in the United States: who provides the care? *Clin Orthop*, 385: 52-6. doi: 10.1097/00003086-200104000-00010. PMID: 11302326.
12. Archer J (2010) State of the science in health professional education: effective feedback. *Med Educ*, 44: 101-8. doi: 10.1111/j.1365-2923.2009.03546.x. PMID: 20078761.
13. Ramaprasad A (1983) On the definition of feedback. *Behav Science*, 28: 4. <https://doi.org/10.1002/bs.3830280103>
14. Bloom BS, Englehart MD, Furst EJ, Hill WH, Krathwohl DR (1956) *Taxonomy of educational objectives: the classification of educational goals. Handbook I: Cognitive domain.* London: Longmans, Green and Co LTD.
15. Krathwohl DR (2002) A revision of Bloom's taxonomy: an overview. *Theory Pract.* 41: 212-8.
16. Coughlin PA, Featherstone CR (2017) How to write a high quality multiple choice question (MCQ): a guide for clinicians. *Eur J Vasc Endovasc Surg.* 54: 654-8. doi: 10.1016/j.ejvs.2017.07.012. Epub 2017 Sep 1. PMID: 28870436.
17. Cunnington JPW, Norman GR, Blake JM, Dauphinee WD, Blackmore DE (1996) Applying learning taxonomies to test items:

Is a fact an artifact? *Acad Med.* 71: S31 -33. . doi: 10.1097/00001888-199610000-00036. PMID: 8940927.

18. Bibler Zaidi NL, Grob KL, Yang J, Santen SA, Monrad SU et al. (2016) Theory, process, and validation evidence for a staff-driven medical education exam quality improvement process. *Medical Science Educator.* 26: 331-6. DOI: 10.1007/s40670-016-0275-2

19. Bibler Zaidi NL, Monrad SU, Grob KL, Gruppen LD, CherryBukowiec JR et al. (2017) Building an exam through rigorous exam quality improvement. *MedSciEduc.* 27: 793-8. DOI: 10.1007/s40670-017-0469-2

20. Tractenberg RE, Gushta MM, Mulrone SE, Weissinger PA (2013) Multiple choice questions can be designed or revised to challenge learners' critical thinking. *Adv Health Sci Educ Theory Pract.* 18: 945-61.

21. Epstein RM (2007) Medical education - Assessment in medical education. *New England Journal of Medicine,* 356: 387-96. DOI: 10.1056/nejmra054784. PMID: 17251535.

22. Vleuten C Van Der (1996) The assessment of professional competence: developments, research and practical implications. *Advances in Health Sciences Education,* 1: 41-67. <https://doi.org/10.1007/BF00596229>

23. Gajjar S, Sharma R, Kumar P, Rana M (2014) Item and Test Analysis to Identify Quality Multiple Choice Questions (MCQs) from an Assessment of Medical Students of Ahmedabad, Gujarat. *Indian J Community Med.* 39: 17-20. doi:10.4103/0970-0218.126347.

24. Case SM, Swanson DB (2002) National Board of Medical Examiners, *Constructing Written Test Questions For the Basic and Clinical Sciences, Third Edition (revised).* Philadelphia, USA: National Board of Medical Examiners® (NBME®); 2002.

25. Schmidmaier R, Eiber S, Ebersbach R, Schiller M, Hege I, Holzer M, et al. (2013) Learning the facts in medical school is not enough: which factors predict successful application of procedural knowledge in a laboratory setting? *BMC Med Educ.* 13: 28. <https://doi.org/10.1186/1472-6920-13-28>

26. Vanderbilt AA, Feldman M, Wood IK (2013) Assessment in undergraduate medical education: a review of course exams. *Medical Education Online,* 18: 20438.

27. Bridge PD, Musial J, Frank R, Thomas R, Sawilowsky S (2003) Measurement practices: Methods for developing content-valid student examinations. *Medical Teacher.* doi: 10.1080/0142159031000100337. PMID: 12893554.

28. Haladyna TM, Downing SM (2006) *Handbook of test development.* Mahwah, N.J: L. Erlbaum. <https://doi.org/10.7275/swgt-rj52>

29. Scully, Darina (2017) "Constructing Multiple-Choice Items to Measure Higher-Order Thinking," *Practical Assessment, Research, and Evaluation:* 22. <https://doi.org/10.1007/BF00117714>

30. Sadler D (1989) Formative assessment and the design of instructional systems. *Instr Science* 18: 119-44.

31. Rolfe I, McPherson J (1995) Formative assessment: how am I doing? *Lancet,* 345: 837-9. [https://doi.org/10.1016/S0140-6736\(95\)92968-1](https://doi.org/10.1016/S0140-6736(95)92968-1).

32. Schultz P, Davis H (2000) Emotions and self-regulation during test taking. *EducPsychol,* 35: 243-56. DOI: 10.1207/S15326985EP3504_03

33. Epstein ML, Lazarus AD, Calvano TB, Matthews KA, Hendel RA (2002). *Immediate Feedback Assessment Technique Pro-*

- motes Learning and Corrects Inaccurate first Responses. *The Psychological Record*, 52: 187-201.
34. Higgins E, Tatham, L (2003) Assessing by multiple choice question (MCQ) tests at Manchester Metropolitan University Illinois State University (2001). Centre for the Advancement of Teaching.
35. Kuechler WL, Simkin MG (2003) How Well Do Multiple Choice Tests Evaluate Student Understanding in Computer Programming Classes? *Journal of Information Systems Education*. West Lafayette: Winter 2003. 14: 389. doi: 10.1187/cbe.16-12-0339
36. Ericsson KAJMe (2007) An expert-performance perspective of research on medical expertise: the study of clinical performance. *J medical education*. 41: 1124-30.
37. Hattie J, Timperley H (2007) The power of feedback. *J Review of educational research* 77: 81-112. DOI: 10.1111/j.1365-2923.2007.02946.x
38. Hift RJ (2014) Should essays and other “open-ended” - Type questions retain a place in written summative assessment in clinical medicine? *BMC Med Educ*.14: 249. DOI:https://doi.org/10.1186/s12909-014-0249-2
39. Singh T, Anshu (2009) Internal assessment revisited. *Natl Med J India* 22: 82-410.
40. Beghi M (1989) Multiple choice questions in educational assessment: Proposal of a computerised programme. *Minerva Chir* 44: 1435-9. PMID: 2771090.
41. Ericsson KAJMe (2007) An expert-performance perspective of research on medical expertise: the study of clinical performance. *J medical education*. 41: 1124-30. doi: 10.1111/j.1365-2923.2007.02946.x. PMID: 18045365.
42. Hattie J, Timperley H (2007) The power of feedback. *J Review of educational research*.77: 81-112. https://doi.org/10.3102/003465430298487
43. Hift RJ (2014) Should essays and other “open-ended” - Type questions retain a place in written summative assessment in clinical medicine? *BMC Med Educ*. 14: 249. https://doi.org/10.1186/s12909-014-0249-2
44. Singh T (2009) Anshu Internal assessment revisited. *Natl Med J India*, 22: 82-41045. DOI:10.5005/jp/books/11647_5
45. McCoubrie P (2004) Improving the fairness of multiple choice questions: a literature review. *Med Teach*, 26: 709-12. DOI: 10.1080/01421590400013495
46. Al-Rukban MO (2006) Guidelines for the construction of multiple choice questions tests. *J Family Community Med*.13: 125-33. PMID: 23012132; PMCID: PMC3410060.
47. Feda Makkiyah (2021) Correlation MCQ With Other Assessment Of First Year Medical Students. Seminar Nasional Riset Kedokteran (SENSORIK II).
48. Bhatt M, Dua S (2016) Use of multiple choice questions during lectures helps medical students improve their performance in written formative assessment in physiology. *National Journal of Physiology, Pharmacy and Pharmacology*, 6: 576-80. DOI:10.5455/njppp.2016.6.0514029062016
49. Singh A, Katyal R, Chandra S, Joshi HS, Singh K (2017) Study of impact of vertical integration in medical education in a medical college of India. *Int J Community Med Public Health* 4: 3328-31. https://doi.org/10.18203/2394-6040.ijcmph20173839

50. Rai Dr N, Rai Dr N (2019) Multiple Choice Questions: As Formative Assessment. *International Journal of Medical and Biomedical Studies*, 3. <https://doi.org/10.32553/ijmbs.v3i3.137>

51. Mistilina Sato, Janet Coffey & Savitha Moorthy (2005) Two teachers making assessment for learning their own, *The Curriculum Journal*, 16: 177-91. DOI: 10.1080/09585170500135996