Journal of Contemporary Medical Education
www.scopemed.org
DOI: 10.5455/jcme.20140625074836

Original Research

GESDAV

Making concepts of medical biochemistry by formulating distractors of multiple choice questions: Growing mighty oaks from small acorns

Soundravally Rajendiren, Pooja Dhiman, Suryapriya Rajendiren, Anithasri Rahul, Yuvaraj Balan, Bobby Zacharia, P. H. Ananthanarayanan, Sweta Kulkarni

ABSTRACT

Background: Multiple choice questions (MCQs) have routinely been used for formative evaluation and selection purposes. Enormous efforts are required to produce MCQs with plausible distractors, which test the understanding of concepts and problem solving abilities, without being trivial or giving clues to the correct answer. A thorough knowledge of the concerned topic is a prerequisite for the setter. Therefore in the present study, we observed the effect of formulating distractors of the given MCQs on understanding of a particular topic ("enzymes") of medical biochemistry in undergraduate medical students. **Materials and Methods:** This study was carried out in the Department of Biochemistry in Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India, and involved 135 first year medical students. Students were divided into three groups based on their internal assessment (IA) performance: High performers with >75% IA ($n = 44$), medium performers with IA 60-75% ($n = 48$), and low performers with IA <60% ($n = 43$). The study was conducted in four components. In the first component, a pre-test of 15 MCQs on enzymology was conducted. Next day, as a part of second component, three groups of students were made to sit in different classrooms. They were given the stem of MCQs from the same topic and were instructed to formulate three distracters and one key using their textbooks without peer consultation. At the end of this exercise, each student read out the distracters formed by them and were discussed with the teaching faculty. In the third component, first post-test was conducted the next day and in the last component, a delayed post-test was conducted a week later. Paired *t*-test and one-way analysis of variance was used to find significance. $P < 0.05$ was considered to be statistically significant. **Results:** There was a statistically significant difference between pre-test and post-test in all the high performers and low performers. Furthermore, the retention of performance was seen in all the three groups as there was no statistically significant change in the delayed post-test performance ($P > 0.05$) compared with the first post-test. Although there was no statistical significance between the gain obtained by all the three groups, appreciable gain was observed for medium performers (+1.0698) and low performers (+0.755). **Conclusion:** Formulation of distracters of MCQs for a given stem enhanced the comprehension and performance of medical undergraduate students in medical biochemistry.

KEY WORDS: Biochemistry, distractors, enzymes, formulation, multiple choice questions

Department of Biochemistry, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India

Address for correspondence:
Soundravally Rajendiren, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India.
E-mail: soundy27@yahoo.co.in

Received: January 24, 2014
Accepted: June 25, 2014
Published: July 07, 2014

INTRODUCTION

Teaching medical biochemistry to the undergraduate medical students in their preliminary stages of medicine is a challenging task. To learn biochemical concepts in the 1st year of the course and relate it to the medical concepts in the 4th and 5th year becomes challenging for the students. This often leads to a superficial gain of concepts of biochemistry and promotes rote learning. It, therefore, becomes an uphill task for the medical teacher to ingrain deeper understanding of clinically relevant areas of the subject. In order to overcome these issues, in the recent years, various new methods have evolved in graduate medical education, along with the conventional didactic teaching. These include formulation of multiple choice questions (MCQs), problem based learning, small group discussions, team-based learning, and computer assisted

learning [1-4]. Introduction of online courses for large scale participation like massive open online course has opened new avenues in education [5].

MCQs have routinely been used for both teaching as well as formative evaluation and selection purposes, by virtue of being objective and timesaving in nature. Properly constructed MCQ has the capability to properly judge the performance levels of the students. An MCQ consist of a question (the stem), and three or more options of which one is the best answer (the key) and rest are distractors. Often the emphasis by the teacher is on the construction of stem, than the distractors. Enormous efforts are required to produce MCQs with plausible distractors, which test the understanding of concepts and problem solving abilities, without being trivial or giving clues to the correct answer. A thorough knowledge of the concerned topic is a prerequisite for the setter. Formulating the distractors and key is the most crucial part of MCQ preparation. It is the quality of distractors which eventually decide the functionality of MCQs [6]. Ideally, distractors should be based on a common misconception about the correct answer. Again, this task requires a thorough knowledge and comprehension of the topic on which MCQs would be made. It has been shown by various groups that if the students were to make their own MCQ's from the given topic, it would improve the in-depth understanding of the given topic [7-11]. There are however limited studies to observe the effects of formulating distractors of the given stem on understanding and retention of core concepts of a given topic.

Hence, in the present study, we observed the effect of formulating distractors of the given MCQs on the understanding of a particular topic of medical biochemistry, and examination performance, in undergraduate medical students.

MATERIALS AND METHODS

This study was carried out in the Department of Biochemistry in Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry, India, and involved 135 first year medical students. Our aim was to test the hypothesis that if the students were made to form distractors for a given stem from the study material and the distractors be discussed by faculty for their merits and demerits, the additive effect of both would enhance their understanding of the topic and improve their performance in examination. Students were divided into three groups based on their internal assessment (IA) performance: High performers with >75% IA (n = 44), medium performers with IA 60-75% (n = 48), and low performers with IA <60% (n = 43). The study was conducted in four components. In the first component, a pre-test of 15 MCQs (Appendix 1) on enzymology was conducted. Next day, as part of the second component, three groups of students were made to sit in three different classrooms. They were given the stem of MCQs from the same topic (Appendix 2) and were instructed to formulate three distractors and one key using their textbooks without peer consultation (individual task). The example of a stem given to the student:

Stem 1: Which of the following enzyme belongs to ligases?

To motivate the students, it was informed to them that some of these MCQ's will be included in their monthly evaluations with the best formed distractor designed by them. At the end of this exercise, each presented the distractors formed by him/her. Subsequently, the teaching faculty discussed the quality of distractors formed. During the discussion, students were made aware of item flaws like use of absolute options (never, all of the above), and repetition of part of stem in distractor. In the third component, first post-test was conducted the next day and in the last component, a delayed post-test was conducted a week later. At the end of the exercise, students were asked to give their feedback on the use of formulating distractors as a learning exercise.

Statistical Analysis

All the data were subjected to D'Agostino and Pearson omnibus normality test. Data analysis was performed in Statistical Package for the Social Sciences version 16.0 (IBM, New York, USA). Paired t-test and one-way ANOVA was used to find significance. $P < 0.05$ was considered as statistically significant.

RESULTS

The marks obtained in pre-test, first post-test and delayed post-test are depicted in Table 1. There was a statistically significant difference between pre-test and post-test in all the high performers and low performers [Table 2]. Also, the retention of performance was seen in all the three groups as there was no statistically significant change in the delayed post-test performance ($P > 0.05$) compared with the first post-test. Gain obtained by all the three groups is depicted in Table 3. Although there was no statistical significance between the groups, appreciable gain was observed for medium performers (+ 1.0698) and low performers (+ 0.755).

DISCUSSION

In the present study, we used formulation of MCQ distractors as a tool to enhance the learning and understanding of the topic of biochemistry (enzymes) in undergraduate medical students. We observed that formulation of distractors for a given stem without peer consultation enhanced the performance of students irrespective of their average performance in the previous assessment, although students with average IA of <75% benefitted the most. This validates the fact that making a well-balanced distractor is not an easy task and requires a lot of efforts by the person formulating them. It requires a deeper

Table 1: Mean and standard deviation of marks (out of 15) in all the three groups

Group	Pre-test	Post-test	Delayed post-test
Total (n=135)	7.15±2.27	7.91±2.12	7.91±2.14
High performers (n=44)	8.13±2	8.84±2.11	8.09±2.22
Medium performers (n=48)	7.10±2.14	7.62±2.17	8.18±2.18
Low performers (n=43)	6.2±2.29	7.27±1.75	7.41±1.96

Table 2: Results of paired *t*-test for all the three groups (*P* value)

Group	Pre-test versus post-test	Post-test versus delayed post-test
High performers	0.005*	0.058
Medium performers	0.076	0.109
Low performers	0.007*	0.0705

*$P<0.05$ is considered statistically significant

Table 3: Mean of the gain obtained by the students after the exercise

Group	Gain from the exercise*
Total	0.704
High performers	0.5208
Medium performers	1.0698
Low performers	0.755

*Post-test, pre-test

level of understanding of the topic to formulate the distractors than to choose one.

The results of our study show that the students obtained sufficient knowledge and comprehension of a given topic to form good quality distractors. Distractors, therefore, contributed to the enhancement of knowledge as evident by the improvement in exam performance. We observed a significant statistical difference in the pre and post-test of the high performers and low performer groups. Although the gain was not statistically significant, there was an appreciable gain in marks for medium and low performers. It would therefore be difficult to say with certainty as to which group was benefitted the most with the exercise. But, it is safe to assume that it would benefit the teachers to conduct such exercises, so as to provide deeper understanding of important concepts of biochemistry. Also, the student levels are personal, and they cannot be forced to jump into a higher level of ranking, a fact, which further compels us not to underestimate the value of distractor formulation.

The medium performers also exhibited an appreciable gain of +1.06 but failed to show any statistical difference between pre-test and post-test scores. This may be attributed to the heterogeneity of the performers in this group, which varied from near 75% to near 60%.

Delayed post-test scores did not show any decline from the previous performance in post-test, in all the three groups, indicating that this exercise can provide fruitful results in retaining the core concepts of a given study topic. Therefore, our goal of retention of information was achieved by formulation of distractors.

Previous studies have demonstrated the usefulness of formulating MCQs as a useful revision exercise for graduate medical students in different subjects [7-11], although the effects of formulation of distractors with the given stem on comprehension and performance of the students have not been studied in detail. The results of our study demonstrate that formulation of distractors for a given MCQ is a thought provoking task, which can help in improving the performance of students.

On evaluation of the feedback for the exercise, we found a mixed response from the students. 55% of the students thought that the exercise was thought provoking and should be included as a learning exercise. Remaining students preferred small group teaching and discussions as a better learning method.

Exposing the students to such unconventional exercises along with regular didactic teaching would act as thought provoking event, and would help them to retain the important concepts without resorting to rote learning. It would also be beneficial for the students to understand the mechanics of good MCQ preparation. This would help them further in their educational pursuits as MCQ's are the most common way of the assessment in specialty and super-specialty gateways. Moreover, formulating a good MCQ would not only provide in-depth understanding, but can also help in terms of analysis and applications of the core concepts. As biochemistry is often regarded as one of the difficult subjects with extensive collections of pathways and enzymes, it would clearly be of benefit for the teacher to adopt such exercises in order to obtain the desired outcome.

It would require efforts on behalf of the faculty to introduce and implement such teaching exercises in education schedule. Lack of enthusiasm in students may be encountered for these unfamiliar exercises, which may abolish as the gain obtained is perceived by the students. The basic idea of our study was supported by various groups who used either formulation of MCQ's or summative exam for a deeper understanding of subject [7-12].

Limitation of the present study is the fact that the same exercise could not be conducted for other topics because of insufficient manpower. Similar exercise conducted for other subjects will help in coming to a discreet conclusion. In the future, we would like to see the gain of students by utilizing this technique for comprehension of all the important topics of medical biochemistry. Also, we would like to conduct studies with randomization of groups and inclusion of both group and individual tasks. For the effective utilization of time, the same exercise can be given as an assignment and later discussion can be carried out by the faculty member.

CONCLUSION

The purpose of the present study was to give an expansive and dynamic view of the basic clinical sciences and to enhance and reinforce their understanding of the same. We observed that, formulation of distractors of MCQs for a given stem enhanced the comprehension and performance of medical undergraduate students in medical biochemistry. We feel that such exercises can be an important ancillary tool in teaching medical biochemistry, along with conventional didactic lectures.

ACKNOWLEDGEMENTS

We acknowledge Dr. Balasubramaninan A, Dr. Prerna Singh and Dr. Archana Nimesh, junior residents, Department of Biochemistry, JIPMER, for their help in carrying out this work.

REFERENCES

1. Hawkins R, MacKrell Gaglione M, LaDuca T, Leung C, Sample L, Gliva-McConvey G, *et al*. Assessment of patient management skills and clinical skills of practising doctors using computer-based case simulations and standardised patients. Med Educ 2004;38:958-68.
2. Pogge E. A team-based learning course on nutrition and lifestyle modification. Am J Pharm Educ 2013;77:103.
3. Cipriano SD, Dybbro E, Boscardin CK, Shinkai K, Berger TG. Online learning in a dermatology clerkship: Piloting the new American Academy of Dermatology Medical Student Core Curriculum. J Am Acad Dermatol 2013;69:267-72.
4. Sé AB, Passos RM, Ono AH, Hermes-Lima M. The use of multiple tools for teaching medical biochemistry. Adv Physiol Educ 2008;32:38-46.
5. Kellogg S. Online learning: How to make a MOOC. Nature 2013;499:369-71.
6. Tarrant M, Ware J, Mohammed AM. An assessment of functioning and non-functioning distractors in multiple-choice questions: A descriptive analysis. BMC Med Educ 2009;9:40.
7. Palmer E, Devitt P. Constructing multiple choice questions as a method for learning. Ann Acad Med Singapore 2006;35:604-8.
8. Bottomley S, Denny P. A participatory learning approach to biochemistry using student authored and evaluated multiple-choice questions. Biochem Mol Biol Educ 2011;39:352-61.
9. Collins J. Education techniques for lifelong learning: Writing multiple-choice questions for continuing medical education activities and self-assessment modules. Radiographics 2006;26:543-51.
10. Bobby Z, Radhika MR, Nandeesha H, Balasubramanian A, Prerna S, Archana N, *et al.* Formulation of multiple choice questions as a revision exercise at the end of a teaching module in biochemistry. Biochem Mol Biol Educ 2012;40:169-73.
11. Sircar SS, Tandon OP. Involving students in question writing: A unique feedback with fringe benefits. Adv Physiol Educ 1999;22:S84-91.
12. Brink J, Capps E, Sutko A. Student exam creation as a learning tool. Coll Stud J 2004;38:262-72.

Source of Support: Nil, Conflict of Interest: None declared.

Appendix 1: Test paper used for pre- and post-exercise

1. Which of the following is a marker of new bone formation?
   a. Aspartate transaminase
   b. Alanine transaminase
   c. Alkaline phosphatase (ALP)
   d. Acid phosphatase
2. Tartrate labile phosphatase is concentrated in the following tissue
   a. Bone
   b. Prostate
   c. Erythrocytes
   d. Platelets
3. Acid phosphatase is elevated in all the following except
   a. Gaucher's disease
   b. Paget's disease
   c. Sickle cell anemia
   d. Hypoparathyroidism
4. Bone diseases with increased a ALP activity are all except
   a. Paget's disease
   b. Bone metastasis
   c. Osteomalacia
   d. Hyperparathyroidism
   e. Osteoporosis
5. Bone diseases with increased ALP activity are all except
   a. Paget's disease
   b. Bone metastasis
   c. Osteomalacia
   d. Hyperparathyroidism
   e. Osteoporosis
6. Flipped pattern of serum lactate dehydrogenase isoforms indicates
   a. Myocardial infarction
   b. Hemolysis
   c. Hepatitis
7. Creatine kinase (CK)-MB/total CK relative index of >6% indicates
   a. Brain injury
   b. Acute myocardial infarction
   c. Severe exercise
8. Isoenzymes differ by all except
   a. Electrophoretically
   b. Immunologically
   c. Molecular weight
   d. Chemical reaction
9. The characteristics of nonfunctional plasma enzymes are all except
   a. Low in circulation in physiological condition
   b. Substrates are not available in blood
   c. Examples are choline esterase
   d. Altered in disease conditions
10. Which of the following is not a method of regulating enzyme activity
    a. Enzyme induction
    b. Covalent modification
    c. Allosteric regulation
    d. Regulatory proteins
11. All are true about chymotrypsin except
    a. Serine protease
    b. The catalytic triad is formed by serine, histidine, aspartate
    c. Diisopropylfluorophosphate inactivates the enzyme by competitive inhibition
    d. Autocatalytic activation
12. The features of abzyme are all except
    a. Bind the substrate
    b. Found in normal humans
    c. Catalytic activity
    d. Resemble transition state

13. The characteristic of allosteric enzymes are all except
    a. Do not follow Michelis Menton hyperbolic curve
    b. Multimeric proteins
    c. Inhibitors shift the curve towards left
    d. Phosphofructokinase is an example
14. The true regarding noncompetitive inhibitor is
    a. Binds to the substrate binding site
    b. Km decreases but Vmax remains same
    c. Vmax decreases but Km remains the same
    d. Both Km and Vmax decreases
15. Regarding Km all are true except
    a. Increase indicates less affinity
    b. Decrease indicates less affinity
    c. Hexokinase has more Km than glucokinase

Appendix 2: Stems given to the students for formulation of distractors

1. All of the following are true about holoenzyme except
2. Which of the following enzyme require magnesium?
3. Which of the following enzyme belongs to ligases?
4. Enzymes involved in oxidation reduction reactions are all except?
5. Which of the following apply to Michaelis and Menton hypothesis?
6. Michaelis and Menton hypothesis states that:
7. Which of these statements is false regarding competitive inhibition?
8. In allosteric inhibition
9. Abzyme is an
10. If chymotrypsin molecule undergoes a serine-195-alanine mutation then:
11. Which of the following is not a rate limiting enzyme:
12. Thrombin activity is inhibited by
13. Enzyme regulated by phosphorylation
14. Not a nonfunctional plasma enzyme
15. True about isoenzymes are
16. Enzymes stored in muscle is
17. Severe muscle exercise causes
18. In which of the following conditions, the creatine kinase-1 increases
19. The predominant isoenzymes of lactate dehydrogenase in cardiac muscle is
20. Increase in the activity of serum alkaline phosphatase is not seen in.