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Research Article

Evaluation of novel methods of assessments in pharmacology to develop new attitudes and skills in Caribbean Medical School

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ABSTRACT

Background: Assessment is said to drive student learning and define the curriculum. The problem-solving type of multiple choice questions (MCQs), which can be used to probe and assess medical students in pharmacology should have a clinical vignette containing presenting complaints, abstract history, physical examination and laboratory data, followed by a single or series of questions based on it. National Board of Medical Examination (NBME), USA has an extensive bank of problem-solving MCQs, and these questions are often regarded as similar in format and focus to MCQs of United States Medical Licensing Examination (USMLE). The objective assessment of teaching and curriculum in this study is done by comparison of students' performance in pharmacology comprehensive exam of NBME, USA before and after curriculum changes. This study was designed to obtain an objective assessment of teaching and curriculum by comparison of students' performance in terms of student mean grades, percentage of students passed, percentage of students failed, percentage of students with honors, and individual highest scores of five semesters before and five semesters after curriculum changes in pharmacology comprehensive exam of NBME, USA among the 5th semester students of American University of the Caribbean, School of Medicine, St. Maarten.
Methods: We have compared the students' performance of pharmacology comprehensive exam of NBME using five parameters like student mean grades, percentage of students passed, percentage of students failed, percentage of students with honor, and individual highest score of five semesters May 2009, September 2009, January 2010, May 2010 and September 2010 semester batches before the introduction of curriculum changes with subsequent semesters January 2011, May 2011, September 2011, January 2012 and May 2012 semesters after the introduction of curriculum changes.
Results: The pre-curriculum student performances were compared with post-curriculum changes using the Student's t-test. The students mean scores improved significantly from 50.76 before curriculum changes to 56.54, students passed (%) increased from 94.57% before curriculum changes to 96.93% after curriculum changes and students with honors (%) increased significantly from 64.72% before curriculum change to 75.51% after curriculum changes and also seem to have remained consistently better. The students failed (%) decreased dramatically from 5.43% to 3.07% after curriculum changes. The highest individual mean score also improved significantly from 72.4 to 80.8 after curriculum changes and have remained consistent in the following semesters.
Conclusions: There seems to be obvious improvements in student performance as reflected by a significant increase in mean scores, students pass (%), and students with honors (%) probably due to inclusion of problem-solving MCQs in formative and summative assessments in new curriculum compared with declarative MCQs in old curriculum. The student failed (%) decreased dramatically, which could be attributed to the changes in teaching content and format brought by curriculum changes in pharmacology. The teaching of pharmacology principles as pathophysiology of drug therapy also seemed to have prepared students better for NBME comprehensive exam and also USMLE Step 1. The clinical pharmacology exercises in small groups as role playing sessions seem to have really improved students' comprehension and retention of the basic sciences knowledge for clinical application based on students' feedback.

Keywords: Pharmacology, Teaching, Assessment, Curriculum, Problem-solving multiple choice questions

INTRODUCTION

Pharmacology is uniquely positioned and occurs at a critical juncture, after completion of most basic sciences courses but before intense clinical experiences has begun. Pharmacology is essentially a second-level application of physiology and biochemistry toward a therapeutic goal. Pharmacology should be taught in the manner in which physician used the knowledge and assessed in the format in which it was taught. Traditional pharmacology teaching is often the drug centered and focuses on the mechanism of action, indications and side-effects of different drugs. However in clinical practice, the reverse approach has to be taken, from the diagnosis to the drug.

One of the important reasons for understanding basic principles of pharmacology is for the safe and effective use of drugs, and at the same time to avoid or lessen a purely empirical approach that entails a long and inefficient period of trial and error.[1] Defects in pharmacology teaching both in methods and content have been identified previously such that theoretical knowledge cannot be applied to clinical practice. There is a high burden of factual information, poor coordination across courses, interdisciplinary rivalry and the artificial divide between basic sciences and clinical sciences. Pharmacotherapy in context learning has a positive effect on learning cognitive therapeutic skills, that is., choosing a drug treatment and also has a high appreciation by students. This effect has been obtained with role play sessions and a minimal study load.[2] The lack of transfer from the classroom to the clinic is not just because students are learning the "wrong" things or in the "wrong" place. Rather, they are learning in a different way that is highly functional for their immediate needs, i.e., exams.[3] It is far easier to learn and remember meaningful information than meaningless information. A more useful method of imposing meaning, therefore, would be to provide the meaning that is available to the expert or at least a reasonable approximation of that meaning. Thus, it is the responsibility of an effective teacher to provide useful meaning for the learner. While much attention has been directed to the process by which medical students are educated, comparatively little attention has been devoted to assessment methods in medical colleges. Assessment is said to drive student learning and define the curriculum.[4] Success in education is largely measured by performance in examinations. The pharmacology assessments (both formative and summative assessments) in most medical schools worldwide have less emphasis on problem-solving multiple choice questions (MCQs). Although, the medical school assessments have MCQs, but they are predominantly of declarative type MCQs, which are neither based on clinical vignettes nor meet good standards. These declarative type MCQs assess mainly factual information based on individual facts rather than utilization of facts to address a clinical condition. It is suggested that storing therapeutic information in a situation format in which the knowledge will be applied benefits the speed and quality of recall.[5] The problem-solving MCQs represent the highest level of cognitive, intellectual activity and can be used to probe and assess medical students.[6] These problem-solving type MCQs usually have a clinical vignette that contains abstract history, physical examination and laboratory data, followed by a single or series of questions based on it.

METHODS

We have compared the students' performance of pharmacology comprehensive exam of National Board of Medical Examination (NBME) of five semesters May 2009, September 2009, January 2010, May 2010 and September 2010 semester batches before the introduction of curriculum changes with subsequent semesters January 2011, May 2011, September 2011, January 2012 and May 2012 semesters after the introduction of curriculum changes. Along with formative examinations, American University of The Caribbean (AUC) continued to administer the NBME comprehensive pharmacology examination at the end of the course to gauge students' preparedness for the United States Medical Licensing Examination (USMLE) Step 1. The mean of Medical College Admission Test (MCAT) scores (24.4 vs. 23.5) and entering undergraduate grade point average (GPA) (3.19 vs. 3.24) did not vary significantly for all the groups in the study. The study was conducted at AUC, School of Medicine, St. Maarten, Caribbean islands and the study protocol was approved by the Institutional Ethics Committee. The pre-curriculum student performance was compared with post-curriculum changes using the Student's t-test.

The curricuum changes in the pharmacology course mainly included the following:

1. Predominantly NBME style problem-solving MCQs in formative and summative assessments of the new curriculum instead of declarative MCQs in the old curriculum (Table 1).
2. Synchronizing the problem-solving MCQs with teaching along with the pathophysiological basis of drug therapy, instead of traditional pharmacology lectures as classification, mechanism, adverse effects and uses of drugs.[7]
3. Small group (15 students) clinical pharmacology exercises every week with role playing sessions.
4. Providing coaching report/feedback report of the examination immediately at the end of the examination and exam review on the following day to ensure the condensation of correct knowledge.[8]
5. Course reorganization to make it more conceptual and comprehensive rather than an exhaustive list of drugs classification, uses and adverse effects.[9]

The NBME, USA committee members conducted a workshop at AUC, School of Medicine, St. Maarten for teaching faculty on "How to create Problem-Solving MCQs'.[10] There has been a lot of change in thinking from assessment of learning to assessment for learning.[11] The 2 days' workshop divided

Table 1: Types of MCQs, declarative MCQs format Type 1 and problem-solving MCQ format Type 2.

Declarative MCQ format Type 1	Problem-solving MCQ format Type 2
Which of the following is the most serious adverse effect of metformin? A. Agranulocytosis B. Cardiac arrhythmias C. Hepatotoxicity D. Lactic acidosis E. Nephrotoxicity	A 51-year-old female presented to the emergency department with severe dyspnea. She has past medical history of Type-2 diabetes mellitus and hypertension. She is regularly taking atorvastatin, hydrochlorothiazide, pioglitazone, metformin and enalapril for the last 2 years. Further questioning revealed that she underwent diagnostic coronary angiogram 2 days back. Chest X-ray appears normal and electrocardiography does not show any ST segment changes. Laboratory evaluation reveals serum troponin I: 5 µg/L (normal, <10 µg/L), troponin T: 0.01 µg/L (normal, <0.1 µg/L) CK-MB type of 0.8 ng/mL (normal, <3 ng/mL), ALT 51 U/L (normal, 7-56 U/L), blood pH of 7.25, a serum bicarbonate level of 14 mEq/L (normal, 22-26 mEq/L), a serum lactate level of 5 mmol/L (normal, <2 mmol/L) and an anion gap of 19 mEq/L (normal, 8-12 mEq/L). Which of the following medications most likely responsible for this untoward incident? A. Atorvastatin B. Enalapril C. Hydrochlorothiazide D. Pioglitazone E. Metformin
This MCQ format Type 1 is commonly used in most medical and postgraduate medical entrance exams	This MCQ format Type 2 is recommended by NBME, and used in USMLE
Assess factual information based on individual facts	Assess problem-solving skills, requires integration of information to arrive at logical conclusion.[14]
This declarative MCQ format Type 1 encourages rote memorization	This problem-solving MCQ format Type 2 fosters the development of reasoning capabilities and modifies learning behavior

MCQs: Multiple choice questions, USMLE: United States Medical Licensing Examination, NBME: National Board of Medical Examination, CK-MB: Creatine kinase-MB, ALT: Alanine transaminase

the teaching faculty members into four groups (each group having faculty from basic sciences discipline and clinical sciences). This workshop provided a platform for creating guidelines for constructing a context rich, problem-solving MCQs with less technical flaws to improve validity evidence of MCQs.[7,12,13] The usual guidelines put forward by NBME for constructing problem-solving MCQs are:

1. MCQs should have a clinical vignette with presenting symptoms and signs, abstract history, laboratory values, along with probable or certain diagnosis.
2. MCQs with the clinical vignette can be used very effectively to simulate clinical scenarios and to assess the preferred treatment, alternative regimen in case of drug allergy or special population such as pregnant women, drugs causing the adverse effects and any other questions relevant to pharmacology.
3. MCQs of problem-solving type are encouraged to have answer options of equal length and also arranged alphabetically to avoid any clues to the students.
4. Avoid using "Only" "Must" "All of the following" "None of the above" in answer options of problem-solving MCQs.
5. MCQs with answer options having numerical values, if any, should be in either increasing or decreasing order to provide consistency.

Thus, the curriculum changes in pharmacology course entailed two major changes: firstly, efforts were being made to better integrate content, discuss pathophysiology of drug therapy, optimize its timing, and avoid unintended duplication; secondly, students' assessments were based predominantly on problem-solving MCQs in both formative and summative assessments instead of declarative MCQs in the old curriculum.

RESULTS

AUC, School of Medicine, St. Maarten, Caribbean islands experienced a variable enrollment for each semester. This study involved a total of 1104 students including 516 students in pre-curriculum cohort and 588 in post-curriculum cohort. Each of the semester cohorts participated in the study had a different number of students but the general "profile" of learners did not change. The mean of MCAT scores (24.4 vs. 23.5) and entering undergraduate GPA (3.19 vs. 3.24) did not vary significantly for all the groups in the study. As hypothesized, we documented a significant increase in students' mean scores in comprehensive pharmacology NBME exam from 50.76 in pre-curriculum changes group to 56.54 in post-curriculum changes group, which gets translated into an increase in 11.38% as shown in Table 2.

Table 2: Comparison of students' performance of five semesters (mean) pre-curriculum cohort and five semester (mean) post-curriculum cohort.

	Pre-curriculum cohort	Post-curriculum cohort
Total number of students	516	588
Students grades (mean) (%)	50.76	56.54 (11.38)*
Standard deviation	6.88	9.54
Total number of students failed (%)	28 (5.43)	18 (3.07)*
Total students with honors (%)	334 (64.72)	444 (75.51)**
Individual highest scores (mean)	72.4	80.8 (11.60)**
Total number of students passed (%)	488 (94.57)	570 (96.93)

Values in parenthesis indicate percentages. *p<0.05 was considered significant and p<0.001 highly significant

The total number of failed students decreased from 28 in pre-curriculum change group to 18 in post-curriculum group. The students' failed (%) decreased from 5.43% in pre-curriculum changes group to 3.07% in post-curriculum group as depicted in Tables 2 and 3. The cut off score to pass pharmacology comprehensive NBME examination was 40, which was based on United States national average over the preceding 2 years. The total number of students with honors increased from 334 in pre-curriculum change group to 444 in post-curriculum change group. Thus, the students with honors (%) increased from 64.72% before curriculum changes to 75.51% after curriculum changes. The student score of ≥65 on pharmacology subject examination conducted by NBME is regarded as honors based on conversion scale provided by NBME. The highest individual score (mean) also significantly increased from 72.40 in pre-curriculum group to 80.80 in post-curriculum group with a significant increase by 11.60%. The total number of students passed increased from 488 in pre-curriculum group to 570 in post-curriculum group. The percentage of the students passed improved from 94.57% before curriculum changes to 96.93% after the curriculum changes.

DISCUSSION

The MCQ type of tests represents one of the most important examination tools that are commonly used worldwide in assessing medical knowledge. They could be used to measure the important educational outcomes-knowledge, understanding, judgment and problem-solving. The MCQs can be reliable, valid, and cost-effective in assessing medical knowledge.[15] The purpose of this study was to explore the influence of curriculum change including assessment methods on students' comprehension and retention of basic

Table 3: Semester-wise performance of students in pharmacology comprehensive NBME examination before and after curricular changes.

	Semesters before curriculum changes					Semesters after curriculum changes				
	May 2009	September 2009	January 2010	May 2010	September 2010	January 2011	May 2011	September 2011	January 2012	May 2012
Total number of students	102	88	152	98	76	146	87	85	161	109
Student grades (mean)	51.8	51.2	49.6	50.4	50.8	55.1	55.6	55.2	58.2	58.6
Standard deviation	5.9	5.2	10.3	6.2	6.8	10.1	8.2	9.1	9.5	10.8
Number of students failed (%)	5 (4.91)	4 (4.55)	9 (5.92)	6 (6.13)	4 (5.26)	7 (4.80)	3 (3.45)	2 (2.35)	4 (2.49)	2 (1.84)
Students with honors (%)	64 (63.21)	55 (62.10)	100 (65.70)	65 (66.50)	50 (65.78)	102 (69.86)	64 (73.56)	65 (74.71)	129 (80.12)	84 (77.02)
Individual highest scores	69	72	74	72	75	74	75	82	85	88
Number of students passed (%)	97 (95.09)	84 (95.45)	143 (94.08)	92 (93.87)	72 (94.74)	139 (95.20)	84 (96.55)	83 (97.65)	157 (97.51)	107 (98.16)

Values in parenthesis indicate percentages. NBME: National Board of Medical Examination

sciences information as measured by students' performance in pharmacology comprehensive NBME exam. This study also generates information to support recommendations for improving curriculum delivery. Assessment has a powerful influence on curriculum delivery. Medical instructors must use tools that conform to educational principles, and audit them as part of curriculum review.[16] While the impact of transitioning of pharmacology curriculum and grading scheme from a declarative type MCQs to problem-solving type MCQs systems-based model is challenging to quantify, marked improvement in students' performance in NBME pharmacology comprehensive examination scores were found as indicated by a significant increase in mean scores, percentage of students with honors and highest individual scores. There was a dramatic drop in the percentage of students also failed. It is certainly possible that synchronizing the teaching to problem-solving type MCQs format led to improved student learning and improved exam performance. Anecdotal accounts indicate that students' study strategies may have changed and contributed in better response to the new curriculum. The possibility that assessment method changes resulted in increased student performance is plausible, since assessment is often thought to drive learning and can influence student study patterns. In any medical school curriculum, student study time is a finite resource that learners must allocate accordingly. Our study results demonstrate that students' mean scores, percentage students passed and percentage students with honors improved significantly after curriculum changes by including problem-type MCQs in both formative and summative assessments and also teaching pathophysiological basis of drug therapy. The students also expressed that the information was more lucid, comprehensive and concrete after the curriculum changes. Most students also commented in their semester evaluation that they enjoyed the pharmacology lectures, which was reflected by an improvement in students' attendance when compared with previous semesters. One of the important aspects of curriculum change was also to encourage faculty to discuss at least one problem-solving type MCQ towards the end of the lecture to make the learning more interactive and maintain student interest towards the end. Students showed deep appreciation for this revision of lecture using MCQs format during regular lecture as an added advantage to underline the take home message. As hypothesized, learners' performance on the NBME pharmacology comprehensive exam, in the first cohort of students in the new modified curriculum scored significantly ($p \leq 0.05$) higher than the previous pre-curriculum change cohort. Subsequent cohorts showed the same pattern, suggesting that the change was probably real, and not due to a simple observation effect. In summary, the reasons for the observed changes may remain conjectural, and our analysis of this curricular change, perhaps raises more questions than it answers. Nonetheless, the take-home message is that assessment method is a powerful driver of student effort and learning, and should be appropriately balanced. There is a need to review the quality, including the content of assessment tools. The principles of effective test item writing of problem-solving MCQs have been documented; violations of these principles are common in medical education.[17] Guidelines for problem-solving MCQs test construction are related to development of educational objectives, defining levels of learning for each objective, and writing effective MCQs to test that learning. A structured faculty development program is recommended for developing improved assessment tools that align with learning outcomes and measure competency of medical students.[18] Every format type of MCQs, declarative and problem-solving type MCQs has its own advantages/disadvantages and a combination of these formats based on rational selection is more useful and hence should be adopted by the medical school curriculum.[19] There are studies, which emphasizes that the selection of quality MCQs truly assess the knowledge and are able to differentiate the students of different abilities in correct manner.[20] Future studies on the effects of curriculum change on student performance should consider the specific roles of assessment methods and study strategies on how students learn and allocate their time.

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