Multiple choice questions: Can they examine application of knowledge?

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Abstract
Background: Multiple choice questions (MCQ) provide an ideal vehicle with which to assess "body of knowledge", however, one of the key questions is that of MCQ and their assessment beyond basic knowledge recall. This study has allowed exploration of knowledge recall as opposed to application of knowledge in student subgroups i.e. international students as opposed to local students.
   Aim: This paper describes a study which explores the use of MCQ in a Pharmacy program to assess the application of knowledge.
   Results: The data indicates that questions which require application, analysis, synthesis and evaluation can be used in the assessment of Pharmacology subject materials in a Pharmacy program. International students achieve a similar percentage of application of knowledge questions correct as do local students, however, attention needs to be paid as to whether questions are assessing application of pharmacology knowledge or application of pharmacology knowledge and language proficiency.

Keywords: *Multiple choice questions, pharmacy program, feedback, assessment, pharmacology*

Introduction

This article describes a study which explores the use of multiple choice questions (MCQ) in Pharmacy programs to assess the application of knowledge. A mix of MCQ and short written free response questions have been used in final examination assessment of Pharmacology in the Bachelor of Pharmacy program at the University of South Australia for the past 10 years. A body of data has been accumulated around internal quality control for the MCQ. For example, analyses of item difficulty and discrimination of each question is routinely provided through the computer based marking assessment software.

   With increasing student numbers, in the interests of expediency, the Pharmacology teaching team are now using MCQ more frequently throughout the Semester in both online quizzes and tests, thus providing feedback to students around their learning. MCQ provide an ideal vehicle with which to assess "body of knowledge". Various texts are available which detail the features of "good" MCQ (Kehoe, 1995, Case & Swanson, 2002), therefore, questions can be well written, however, one of the key questions is that

of MCQ and their assessment beyond basic knowledge recall. Problem solving requires that students are able to apply, analyse and synthesise information.

   For Australian Pharmacy schools, graduate qualities or attributes, which invariably include problem solving skills, align with the clearly articulated goal of educating prospective pharmacists who possess both a sound pharmaceutical knowledge base and a set of skills to enable professional practice. The Pharmaceutical Society of Australia in "Competency Standards for pharmacists" (Competency Standards for Pharmacists in Australia, 2003) has outlined within their key statement for the profession "effective problem solving, organisational, communication and interpersonal skills, together with an ethical and professional attitude ..." as essential to the profession of pharmacy.

   There has been minimal evaluation reported in pharmacy literature about the use of MCQ to explore higher order cognitive levels. In medical education, it has been reported that MCQ "can be used in any form of testing, except when spontaneous generation of the answer is essential, such as in creativity, hypothesising, and writing skills" (Schuwirth & van der Vleuten,

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2003). It is therefore appropriate to ask whether MCQ, which test higher order cognitive thinking, can be written to test Pharmacology subject material and more importantly used successfully in administered MCQ tests and exams. The study described in this paper seeks to examine the use of MCQ in Pharmacy programs to assess the application of knowledge.

This study has also allowed exploration of knowledge recall as opposed to application of knowledge in student subgroups i.e. international students as opposed to local students. Student groups involved have a high proportion of international students who may present with problematic language proficiency and learning styles and attitudes at odds with those of an English speaking background student who has matriculated within the Australian secondary system (Ballard, 1995). Students from a primarily South East Asian, non English speaking international background are often stereotyped as passive, rote learners (Ballard, 1995). This is obviously incompatible with application of knowledge as opposed to knowledge recall. No reports have been published with respect to application of knowledge abilities in such a group of students for Pharmacy programs in Australia or elsewhere.

Method

A bank of MCQ has been developed by Pharmacology teaching team staff over the past 10 years. Items are revised on the basis of new pharmacology knowledge and in response to student performance for each MCQ. Questions to be included in a particular test or exam paper are selected by the academic responsible for delivery of the corresponding lecture content to be examined. The questions were of a standard, which, based on compiled data, would be expected to give questions which would give the percentage of students selecting the correct answer between 20 and 80%.

Completed MCQ test and exam papers administered to third year Pharmacy students at the University of South Australia in 2004 and 2005 were marked by Educational Assessment Australia, University of NSW, Australia. Data provided by Educational Assessment Australia include individual student scores and mark distributions. Item analysis includes percentage of students choosing the correct option and the biserial correlation for that item. Discriminator analysis is also provided, as is the KR20 for the test/exam overall. Item analysis data was collated.

Individual MCQ in test and exam papers were scored as A or K by two "blind" academic staff (Staff A and Staff B) who teach in the Pharmacy program, however, do not teach in the Pharmacology courses and have no association with these courses.

They were provided the following instructions.

1. If to answer a question knowledge/comprehension are required please indicate K next to the question.

2. If to answer a question application/analysis/synthesis/evaluation are required please indicate A next to the question.
3. Please do not discuss your decisions with others.

These two staff members were also provided with a single page summary which describes levels of thinking/learning (Mennin & Richter, 2003). Information provided in this summary includes definitions of each category level (knowledge, application and problem solving) and provides example objectives.

These quantitative and qualitative data were collated for MCQ used in all pharmacology exams and tests in 2004 and Semester 1 2005. For some analysis, students were grouped according to international or local student status.

Results

Two staff members were asked to independently score questions as K (knowledge/comprehension are required) or A (application/analysis/synthesis/evaluation are required). Of the 336 questions scored, Staff A indicated that 55 required application of knowledge, whereas Staff B indicated that 27 required application of knowledge. Twenty six of these 27 questions were also allocated to the application category by Staff member A, i.e. only one question allocated to the application category by Staff B was not similarly allocated to this group by Staff A. These data indicate differences in allocation; however, the allocation categories of both staff were used to further investigate differences in student's abilities to answer both the knowledge and the application questions.

Collated data for tests and exams showing percentages of students indicating the correct answer for each question over three semesters are shown in Table I. The percentage of students indicating the correct answer for questions designated K or A is also tabulated. There is no significant difference between the percentages of questions correct between all questions and questions allocated as knowledge questions or as application of knowledge questions.

The ten questions designated as application of knowledge by both Academic A and B in the Semester 1 examination, 2005 were further examined for potential differences between our international and local student cohort. Results are shown in Table II. There was no difference between the local and international students with respect to the percentage of MCQ correct in this examination. Further analysis of each of the ten questions indicated that the performance of both groups is comparable. Question 9 (one of the application of knowledge questions which showed a large difference in percentage correct between the two groups) and question 15 (an application of knowledge question which showed

Table I. Collated data for all questions, questions allocated to knowledge and application of knowledge subgroups by two independent academic staff. S1, Semester 1; S2, Semester 2.

Test/exam and KR20	% Correct all questions (Number of questions in test/exam)	% Correct Staff A knowledge questions (Number allocated to K group)	% Correct Staff A application questions (Number allocated to A group)	% Correct Staff B knowledge questions (Number allocated to K group)	% Correct Staff B application questions (Number allocated to A group)
Test 1, S 1 2004; KR20 = 0.68	71.6 ± 16.6 (20)	73.1 ± 14.3 (18)	62.7–84.3 (2)	71.6 ± 16.6	No questions allocated to this group
Test 2, S1 2004; KR20 = 0.70	59.6 ± 18.8 (30)	60.4 ± 19.9 (26)	55.0 ± 8.6 (4)	60.0 ± 19.1 (29)	54.2 (1)
Exam, S1 2004 KR20 = 0.86	57.9 ± 22.2 (80)	62.2 ± 21.8 (61)	47.6 ± 19.0 (19)	59.0 ± 22.6 (74)	45.2 ± 17.6 (6)
Exam, S2 2004 KR20 = 0.82	66.8 ± 21.3 (80)	66.8 ± 21.3 (77)	76.7 ± 15.2 (3)	76.7 ± 15.2 (78)	65.9–87.4 (2)
Test 1, S1 2005; KR20 = 0.39	71.5 ± 19.9 (20)	76.6 ± 18.3 (9)	67.3 ± 20.9 (11)	78.6 ± 16.5 (14)	54.9 ± 17.9 (6)
Test 2, S1 2005; KR20 = 0.81	70.3 ± 14.7 (30)	70.75 ± 14.9 (28)	55.3–73.2 (2)	70.8 ± 14.9 (28)	55.3–73.2 (2)
Exam, S1 2005 KR20 = 0.82	66.2 ± 19.9 (76)	66.8 ± 19.6 (62)	63.7 ± 21.1 (14)	66.0 ± 19.4 (66)	67.8 ± 23.0 (10)

Table II.   Collated data, S1 2005 exam. Ten questions (as indicated below) were allocation to the application of knowledge subgroup by both Academic A and B.

		Local students [n=50]	International students [n=72]
Number of questions correct in examination paper (Number of questions in paper)		49.6 ± 8.4 (76)	49.7 ± 8.7 (76)
Number of students answering individual application of knowledge question correctly (% correct)	Question 2	42 (84)	68 (94)
	Question 5	43 (86)	62 (86)
	Question 9	44 (88)	50 (69)
	Question 13	27 (54)	37 (51)
	Question 14	41 (82)	61 (84)
	Question 15	28 (56)	41 (56)
	Question 18	16 (32)	14 (19)
	Question 19	41 (82)	64 (88)
	Question 21	39 (78)	66 (91)
	Question 73	17 (34)	23 (31)

no difference in percentage correct between the two groups) are further discussed below.

Discussion

Examination of the collated data indicates that questions which require application, analysis, synthesis and evaluation can be used in the assessment of Pharmacology subject materials. Analysis indicates that student marks for "problem solving" MCQ are not significantly different to those MCQ which require the lower level cognitive levels of knowledge and comprehension.

The allocation of MCQ to either the category of knowledge or application of knowledge categories by the two staff members asked to categorise the questions, indicates the variability in interpretation of the terms used. The study is the first to be reported which examines variability between only two individuals in the allocation of the relatively simple concepts of "problem solving " or "application of knowledge" with respect to MCQ. A more extensive study would be valuable with respect to provision of data about the range of staff allocations and consequently, influences on their understanding of these frequently referred to concepts.

During further analysis of questions requiring application of knowledge two individual MCQ were identified for further inspection. Question 9, which showed a large difference in percentage correct between the international and local student cohorts and question 15, which showed no difference in percentage correct between the two groups. These two questions are shown in the Appendix.

Brief inspection of these two questions indicates issues which may result in the poorer performance of the international student cohort. Their poorer language proficiency may infact impair their ability to answer question 9 correctly rather than their lack of pharmacology knowledge.

Data gathered also indicate that the writing of problem solving questions is unlikely to be accidental. Questions written for Test 1, Semester 1 2005 were written specifically to address problem solving as well as body of knowledge. All tests apart from Test 1, Semester 1 2005 had KR 20 indices greater than 0.68. The low KR20 (0.39) determined for Test 1, Semester 1 2005 may reflect an excess of very easy items which therefore did not discriminate between students (one MCQ was answered correctly by all students) or reflect assessment of both problem solving skills and the body of knowledge rather than a unified body of content (Kehoe, 1995).

The study reports data from one site with students taught in a similar manner, year to year, by the same staff. A more extensive study comparing students taught in either a more didactic or challenging manner would be highly informative as to whether these are general observations.

In summary, the data indicate that questions which require application, analysis, synthesis and evaluation can be used in the assessment of pharmacology subject materials. International students in the pharmacy program at the University of South Australia are able to achieve a similar percentage of application of knowledge questions correct as are local students, however, attention needs to be paid as to whether questions are assessing application of pharmacology knowledge or application of pharmacology knowledge and language proficiency.

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Appendix

Questions 9 which a large difference between local and international students was seen and Question 15 which no difference was seen. Correct answers for both questions are show in bold print.

9. Tachyphylaxis is an established pharmacological phenomenon. The following case is an example of tachyphylaxis:

a. Administration of drug E, for example erythromycin, inhibits the cytochromes P450 responsible for the metabolism of drug F to inactive metabolites. When drug F is administered together with drug E an increased pharmacological effect to drug F is observed.

b. Anti inflammatory steroids such as betamethasone are of no use in an asthma attack as they require up to 24 h to show therapeutic effects.

c. **Use of an indirectly acting sympathomimetic amine (SA) three times daily as a nasal decongestant over a period of 4 days leads to SA eventually having no nasal decongestant effect.**

d. Drug D is converted to a single inactive metabolite by P450 catalysed metabolism. Another drug INX, inactivates this particular cytochrome P450. If drug D and drug INX are administered simultaneously, INX will shift the dose-response curve to the right and increase the plasma half life of drug D.

15. A patient stabilised on the anticoagulant warfarin develops epilepsy and so is put on phenobarital. As a result of the obvious drug interaction:

a. the patient bleeds, we need to increase the dose of warfarin;

b. the patient bleeds, we need to decrease the dose of warfarin;

c. **the patient starts developing clots, we need to increase the dose of warfarin;**

d. the patient starts developing clots, we need to decrease the dose of warfarin.