

## RESEARCH

### Effect of Changing from Closed-Book to Formulary-Allowed Examinations

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**Objective.** To determine whether allowing the use of a medicines formulary in examinations modified the learning behaviors and performance of final year pharmacy students, and to investigate student perceptions of the availability of this resource in examinations.

**Methods.** Student performance and examination difficulty (as measured by classification of examination questions as “high” or “low” according to Bloom’s taxonomy) in second semester examinations (formulary-allowed) was compared with first semester examinations (closed-book) in successive years. Students completed a survey on their study and examination approaches and experiences after both semesters.

**Results.** Examinations in semester two had more questions rated higher on Bloom’s taxonomy than semester one examinations. Data was collected from student surveys for closed book examinations (response rate of 25 and 19% in 2015 and 2016 respectively) and open book examinations (response rate of 22 and 15% in 2015 and 2016 respectively). Study approaches, hours studied per week, and anxiety (all self-reported) did not differ between semesters one and two, but more time was spent studying with a formulary by students in semester two compared with semester one. Qualitative analysis of student comments revealed students’ preference for the formulary-allowed examinations, compared to closed-book examinations. The majority (68%) agreed with the statement “Knowing that I will have access to the AMH [Australian Medicines Handbook] during the exams allowed me to pay more attention to higher level skills such as analysis and evaluation”.

**Conclusion.** When students were allowed to use a formulary in examinations, they studied more with their formulary. Students performed similar on examinations with a greater proportion of questions addressing higher Bloom’s taxonomy levels than on comparatively less cognitively challenging closed-book examinations.

**Keywords:** open-book examinations, higher education, assessment, formulary, pharmacy students

## INTRODUCTION

Open-book examinations can be defined as examinations where the use of textbooks, notes, journals and other reference materials during an examination period is allowed<sup>1</sup>. Whilst open-book examinations have existed for many years<sup>2,3</sup>, the use of such examinations as summative assessments in multiple courses in undergraduate pharmacy degrees, to the best of our knowledge, has not been assessed. Reported benefits of open-book examinations include a reduced anxiety level, decreased emphasis on rote learning by students<sup>4</sup>, the encouragement of “a deeper engagement with the course material on the part of the students”<sup>5</sup>, and “thinking at higher cognitive levels”<sup>1</sup>. Moreover, an open-book examination enhances student understanding in a more realistic context rather than just recalling facts<sup>6</sup> and more closely typifies the experience of real-life health practitioners who commonly refer to resources in order to make clinical decisions<sup>7</sup>. Considering the exponential increase in health and clinical knowledge, it is especially important that students are able apply knowledge from reputable sources such as medicines formularies<sup>8-10</sup>.

Prior to 2015, with the exception of one capstone course, all end-of-semester examinations in the Faculty of Pharmacy and Pharmaceutical Sciences at Monash University, Australia, were closed-book. In 2015, students were allowed to bring a medicines formulary (the Australian Medicines Handbook or AMH) into all second semester, fourth year, end-of-semester examinations. Since 1998, the AMH has been an independent and up-to-date source of medicines information for the use of health care professionals. The AMH contains abbreviated monographs on prescription and non-prescription medicines and is one of the main recommended texts for intern and registered pharmacists in Australia. It was hypothesized that allowing a formulary into examinations would encourage deeper engagement of students with the material, as opposed to rote learning, and allow examination questions to be set at a higher cognitive level.

This project sought to investigate the effects of permitting the use of the AMH on student study behaviours, perceptions, and examination performance. Specifically, the primary aim was to determine whether allowing AMH use in examinations improved student learning. A secondary aim was to determine if student self-reported learning behaviors were changed when students knew they had access to an AMH in examinations. A mixed methods approach

was adopted whereby students were asked to complete a survey on their study and examination habits and to comment on their experiences studying for and taking formulary-allowed and closed-book examinations. Student examination performance and assessment item difficulty were compared for fourth year end-of-semester examinations with and without the AMH, ie, semester two versus semester one.

## METHODS

The Bachelor of Pharmacy at Monash University is a four-year degree. There are two 12-week semesters in a year and four courses (called “units” at Monash University) are studied per semester. In the first semester of the fourth year in 2015 and 2016, students undertook three courses of study that each culminated in an end-of-semester examination, as well as a professional experience placement course that was marked as pass or fail only. The three first semester courses covered topics such as drug delivery and development, therapeutics of endocrine and renal, and therapeutics of dermatology and pain. In the second semester, there were four courses each with an end-of-semester examination (Table 1). The four second semester courses covered topics such as medication management/legislation, clinical decision making, therapeutics of neurology and oncology, and therapeutics of mental health. End-of-semester examinations in the fourth year were worth 45-60% of the overall course mark, and students had to achieve a mark of at least 50% in order to pass each course.

The three end-of-semester examinations in semester one in 2015 and 2016 were closed-book. In semester two of 2015 and 2016, students were allowed to refer to an AMH medicines formulary (current version AMH or version from previous year) during examinations. Students were informed at the start of semester two that for all examinations for the upcoming semester, they were allowed to use a “clean” AMH (that is, an AMH with no additional markings, inserts, stickers, or other components).

All examinations contained a mix of multiple choice questions (MCQs) and short answer questions, and went through a quality assurance process that involved checking for constructive alignment and question difficulty by a person with experience in the examination content that did not collate the examination. No specific directive was given to course coordinators to alter question types, except for a discussion prior to semester two commencing that students would have access to an AMH in all their semester two examinations. For each examination, MCQ analytics were checked, including percentage of students that got each question correct, and the discrimination index. When these parameters were low, a decision was made as to whether to exclude the question from the exam. For short answer questions, the average mark for each question was reviewed. No questions were omitted from 2015 and 2016 fourth year examinations. Examinations varied in length from two to three hours, and proportionately in terms of number of questions. All assessments were externally checked by a person from another Australian University as part of a standard course review process, and no issues with the examinations from 2015 and 2016 were identified.

After the conclusion of both examination periods, each student enrolled in fourth year courses was invited to complete one survey per student. The study was approved by Monash University’s Human Research and Ethics Committee (Reference #2015001098). Students provided informed consent through the Monash University online Learning Management System (Moodle) and were made aware that completing the surveys would not impact their grades in fourth year courses.

The survey was divided into four main sections: 1) General questions about age and gender (Table 2); 2) Questions about how many hours per week students studied in the first half (weeks 1-6), the second half (weeks 7-12) of semester, or at the conclusion of the semester/during the examination period (up to four weeks; Table 2); 3) Statements about study approaches taken from the Revised Two-factor Study Process Questionnaire (R-SPQ-2F) developed by Biggs et al<sup>11</sup> (Table 3); and 4) Statements about student examination experiences and perceptions of studying with the AMH (Table 4). Three additional statements relating to student perceptions of the use of the AMH in their examinations were included in the survey following the semester two examination period (see statements 10-12 in Table 4).

Sections three and four were based on a five-point Likert scale (1 = Not at all, 2 = To a small extent, 3 = Somewhat, 4 = To a large extent, 5 = All the time). For sections two, three and four of the survey, students had the opportunity to comment on their responses as it has been reported that when student responses are volunteered in an unstructured way, they may reflect a more student-centred perspective of their experience<sup>12</sup>. Thematic analysis methods were used to identify and report on common themes in the data<sup>11</sup>.

Data was entered into NVivo 12 qualitative analysis software. Following the guidelines of Braun and Clarke<sup>13</sup>, analysis of data was divided into six phases. In the first phase, the lead investigator (DTM), produced initial nodes by reading and rereading student statements (familiarization). In the second phase (initial coding), four investigators (DTM, SC, EY, JLS) independently assigned sections of text to descriptive nodes. New nodes were identified. Once all data was coded and collated, SC and DTM sorted nodes into overarching themes (phase 3: theme identification). In phase 4 (theme review), the candidate themes were refined, removed, merged, or divided, as needed.

The final themes defined were “Study”, “Exams”, and “Role of the AMH” (phase 5: defining and naming themes). To ensure rigour, the student data was re-coded by SC and DTM using the agreed upon themes (phase 6:

final analysis). Full sentences were coded to the nodes, and if the sentence related to more than one node, it was coded to multiple nodes. Consensual validation of the final themes was reached through discussion, and Cohen's Kappa coefficient was used to measure inter-rater reliability. Mean Kappa coefficients for the three themes was 0.88 (SD  $\pm 0.14$ ) for "Exams", 0.84 (SD  $\pm 0.08$ ) for "Study" and 0.90 (SD  $\pm 0.12$ ) for "Role of the AMH".

Questions from fourth year examinations (from both semesters and both years) were categorized as either a lower (understanding, comprehension) or higher (application, analysis, evaluation, synthesis) level of Bloom's taxonomy<sup>14-16</sup> by an independent rater who was unaware which examinations students had access to an AMH (Ms Nicole Eise who has performed this analysis on other exams previously and is a registered pharmacist<sup>14</sup>). Student performance in examinations in the first and second semesters was compared.

The student self-reported number of hours studied was analysed using a one-way analysis of variance (ANOVA) to determine if there were any significant differences between number of hours studied during the time periods leading up to exams, between the two semesters, or across the years. When there was a significant main effect, a post-hoc Tukey multiple comparison test was performed to determine the specific time periods for which the differences were significant.

Statements about study approaches were grouped into categories (deep motive, deep strategy, surface motive, surface strategy) as reported by Biggs et al<sup>11</sup>. A two-way ANOVA was used to determine whether there were any self-reported differences in study approaches between the two semesters and years. Cronbach alpha values were used to measure the internal consistency for each group of statements.

Student performance in examinations in first and second semester courses was compared using a two-way ANOVA, with semester and year as between-subjects factors. A repeated measures ANOVA was used to compare the proportion of higher level Bloom's taxonomy questions across examinations, with semester and year as between-subjects factors. A Holm-Sidak's multiple comparison test was used to determine whether there was a significant difference between semesters of the same year.

## RESULTS

There was no significant effect of year ( $F_{1,10} = .03, p = .86$ ) or semester ( $F_{1,10} = .32, p = .58$ ) in terms of examination marks (Table 1).

Questions from semester one and semester two examinations were evaluated using Bloom's taxonomy, where questions only requiring knowledge or comprehension were classified as lower level Bloom's questions, and questions requiring application, analysis, synthesis or evaluation were classified as higher-level Bloom's questions (Figure 1). A two-way ANOVA found a significant effect of semester (semester one or two) on Bloom's level ( $F_{1,5} = 9.147, p < .05$ ), but no significant effect of year (2015 or 2016) ( $F_{1,5} = 2.018, p > .05$ ). A Holm-Sidak's multiple comparison test revealed a significantly greater percentage of questions of high Bloom's level in semester two exams in 2015 and in 2016 compared to semester one in the same respective year ( $p < .05$  in both years).

Information concerning the age and gender of the students who participated in the study/completed the surveys is shown in Table 2. Responses totalled 109, and ranged from three words, to paragraphs consisting of 7-8 sentences, with the total responses comprising almost 7,300 words.

Regarding student comments on questions in the survey, in 2015 there were 29 text responses to the semester one survey and 41 responses to the semester two survey. In 2016, there were 20 text responses to the semester one survey and 19 responses to the semester two survey.

During the thematic analysis of 109 responses, 151 statements were coded, from which three primary themes were identified: study, exams, and the role of AMH. Within these themes, sub themes were identified. For "study", subthemes were "approaches to learning" (17 statements for open book, 28 statements for closed book), and "quantity and justification" (11 for open book, 22 for closed book). For "exams", subthemes were "positive aspects" (4 for open book, 1 for closed book), "negative aspects" (4 for open book, 7 for closed book) and "thoughts of exam content" (11 for open book, 12 for closed book). For "role of AMH", subthemes were "positive aspects" (10 for open book, 3 for closed book), "negative aspects" (10 for open book, 2 for closed book) and "how AMH was used" (5 for open book, 4 for closed book).

Of the 51 and 13 respondents for semester 2 2015 and 2016 respectively, 13 students indicated that they borrowed an AMH to use in the examinations, and 4 students indicated that they purchased an AMH.

There were no significant differences with regards to self-reported hours of study between the 2015 and 2016 student cohorts, and no significant differences in the self-reported hours of study between first and second semester courses within a particular year. There was, however, a significant difference in terms of the reported number of hours studied per week across the different time periods during semester ( $F_{65,508} = 7.49, p < .001$ , Table 2). A post-hoc Tukey multiple comparison test revealed that students reported studying a significantly greater number of hours per week during the non-teaching week and examination period than they did during the first and last half of the teaching semester ( $p < .001$  for both years of the study).

Approximately half of the coded statements (78 out of 151) related to study. There were 33 statements specifically related to “quantity and justification” that were coded to “time management”. In comments from first semester, a commonly expressed concern related to the perceived disruptive effects of the professional experience placements (PEPs) upon study efforts.

A number of students commented that their study efforts increased significantly towards the end of semester and during the non-teaching week and examination period. There were three comments in semester two pertaining to the perceived disruptive effects of the intern pharmacist application process (for the following year), scheduled during semester. As a result, students may have spent a considerable amount of time studying for and applying for internship positions.

There were no significant difference between types of study approaches between the two semesters ( $F_{1,368} = .05$ ,  $p > .05$ ,  $\eta^2 < .01$ ; Table 3) or between the two years (for example, deep approach  $F_{1,138} = .05$ ,  $p > .05$ ,  $\eta^2 < .01$ ; Table 3).

Of the coded statements, there were 44 statements specifically related to study approaches. Comments from students inferred that a major reason for adopting a greater surface approach to studying was due to time restrictions rather than not finding the material engaging.

Most questions regarding student examination experience did not significantly change between first and second semester (Table 4). A two-way ANOVA revealed that the only significant difference between first and second semester was for the statement “During my study, I frequently referred to an Australian Medicines Handbook (AMH)” ( $F_{1,144} = 17.15$ ,  $p < .0001$ ). A Tukey multiple comparison test revealed that students more frequently used their AMH whilst studying for second semester courses in 2015 ( $p < .01$ ) and 2016 ( $p < .05$ ), but there was no significant differences between students enrolled in the 2015 and 2016 cohorts.

Across both years of the study, 36% of students answered “Not at all” or “To a small extent” with regard to the statement “I prefer open book to closed book exams” in semester one, and this increased to 47% in semester two. Also of note, 61% of students across both years of the study answered “To a large extent” or “All the time” to the statement “Knowing that I will have access to the AMH during the exam allowed me to pay less attention to remembering specific facts”. 68% of students across both years of the study answered “Knowing that I will have access to the AMH during the exams allowed me to pay more attention to higher level skills such as analysis and evaluation”. This indicates that students generally agreed that AMH allowed examinations tested higher-order cognitive thinking.

Among comments referring to the exam, there were 39 (out of 151) which encompassed positive aspects (5), negative aspects (11) and thoughts about the exams (23). Students agreed that, for courses where the AMH was allowed in examinations, examination questions were of a higher Bloom’s level.

Student comments revealed an appreciation that studying with the AMH was beneficial for learning pharmacy information. Whilst there was no significant effect of allowing the AMH into exams on self-reported student anxiety levels, student comments reported beneficial outcomes in terms of decreasing anxiety and stress.

## DISCUSSION

This study reports on the impact of the allowed use of a medicines formulary in examinations undertaken by fourth year Bachelor of Pharmacy students at Monash University. The primary purpose of permitting the use of a formulary in examinations was to emulate the real-world pharmacy environment. The AMH (see <https://amh.net.au/>), which is updated yearly, is a useful resource containing up-to-date medicines information, and this resource is commonly used by practicing pharmacists in Australia. An unrestricted open-book examination approach was eschewed (ie, allowing students to bring *any* materials), as it would have been very difficult for all students to obtain multiple resources, raising equity issues.

Examination performance was not affected in open book examinations where a formulary was allowed compared with closed-book examinations (Table 1). Previous studies have reported an increase<sup>5, 9</sup> and a decrease<sup>10</sup> and no effect<sup>17</sup> on student performance in open book tests compared with closed book tests. In the present study, open book examinations in semester two had a greater number of questions requiring higher-order cognitive skills than closed book examinations in semester one, despite no specific directive given to course coordinators (Figure 1). Closed book examinations in 2015 and 2016 had a similar proportion of exam questions requiring higher-order cognitive skills than in 2014 (Figure 1). One intention of permitting a formulary into examinations was that it would promote the inclusion of a greater number of questions requiring the use of information from the AMH to answer scenario-based questions, more applicable to pharmacy practice, and the observed outcome was the construction of examinations with a greater proportion of questions that address higher cognitive levels. This is consistent with the well-known fact that open-book examinations enable the assessment of higher-order cognitive abilities<sup>18</sup>.

Allowing students to use a formulary in examinations did not decrease self-reported study time-on-task for final year pharmacy students (Table 2). Heijne Penninga et al (2008) proposed that students spend less time studying for open-book tests than closed-book tests because they consider closed-book tests to be more important, and know

they can consult their references if required in an open-book assessment<sup>19</sup>. However, other studies show no difference in time-on-task studying for open-book tests<sup>20, 21</sup>. As the AMH does not contain all information required to successfully complete fourth year pharmacy examinations, students still needed to study information that was not in the AMH for the examinations, which may explain the lack of time-on-task differences in the present study. Alternatively, it may be that students were motivated to study as much for open-book as for closed-book examinations because these closed-book examinations were considered ‘high stakes’ since a greater than 50% result was required to pass the course of study and finish their degree. Another possible reason for the equivalent self-reported times spent studying for AMH-allowed and closed-book examinations is that students in both years of the study were warned from the outset of the potential risk of relying too much on their AMH in an examination. Finally, this equivalence may be indicative of the fact that fourth year pharmacy students are in their final year and are thus have an established study regimen. Future work should investigate these possibilities through pre- and post-examination interviews. It is reasonable to suggest that considering there were four examinations in semester two and only three in semester one, the hours of study should have been greater in semester two.

Previously it has been shown that a deep learning approach is positively correlated, and a surface learning approach is negatively correlated with examination performance<sup>22</sup>. In terms of student self-reported study approaches as measured in the current investigation, there were higher mean scores for “deep approach” than for “surface approach” across both semesters, although there were no significant differences between study motives, strategies or approaches to study within or between the two semesters (Table 3). Given that fourth year pharmacy students were being assessed, it is likely that their study approaches are well established by this time, resulting in the lack of variability between semesters one and two in both years. Students with deep approaches to learning have been shown to perform better on both open- and closed-book examinations<sup>18</sup>. It would be valuable to test this relationship, but due to the anonymous nature of the surveys, a student-specific comparison between learning approach and examination outcomes was not possible, which is a limitation of the current study.

Contrary to previous studies<sup>4, 21</sup>, allowing the use of the AMH in examinations had no significant effect on the self-reported anxiety levels of the respondents (Table 4). This could be due to the fact that students had four examinations in second semester compared with three in first semester. Also, comments collated from students in both years indicated that many were unhappy with the scheduling of the semester two examinations, whereby two examinations were held on consecutive days. Students generally report feeling anxious prior to and during examinations<sup>23</sup>, thus it is highly likely that having a greater number and poorer scheduling of examinations in semester two impacted student anxiety levels. In addition, a number of students commented that during semester two, they had the added stress of interviews for hospital internship positions for their following year. Several student comments indicated a perceived benefit of formulary-allowed examinations, with students reporting a lower level of anxiety, both prior to, and during examinations, although given the low sample size, it is difficult to generalise across the whole student cohort.

As alluded to above, another limitation is the low sample sizes, particularly in semester two in 2016. This may be why the “Examination Satisfaction” Cronbach alpha value was .3 (Table 4). There was also a low Cronbach alpha value (.3) for the 2015 cohort for statements 11 and 12 (Table 4). This may indicate poor interrelatedness between these two items<sup>24</sup>. Given the low response rate, student survey data should not be used to draw definitive conclusions, and it is acknowledged that given the low response rate, the students that did respond may not be reflective of the whole cohort. As alluded to above, another limitation is that courses from semester one were compared with courses from semester two, meaning that some effects (or lack thereof) may have been due to the variability in time of testing. It would have been useful to compare courses within each semester to control for this, however, it was thought that having some examinations with a formulary allowed and some without in the same semester could have caused confusion for students and resulted in lesser amount of study for courses where the formulary was allowed in the examination. A further limitation is that students were asked to recall their number of study hours after the semester had finished, thus possibly leading to recall bias.

## CONCLUSION

With the reported exponential increase in medical knowledge occurring in the current climate<sup>8</sup>, it is imperative that pharmacy schools assess students on their ability to find, analyze, and apply information, rather than only their ability to recall and understand information. The present study demonstrates how the use of a medicines formulary in examinations enables testing students on more cognitively challenging questions without a decrease in examination performance. Self-reported study habits (time-on-task or approach), anxiety levels and learning motivations or strategies also were not affected, albeit the sample size was small. However, students reported studying more with their medicines formulary for end-of-semester examinations when their formulary was permitted for use in the examinations. This research has led to the continual use of the AMH in some pharmacy examinations at Monash University.

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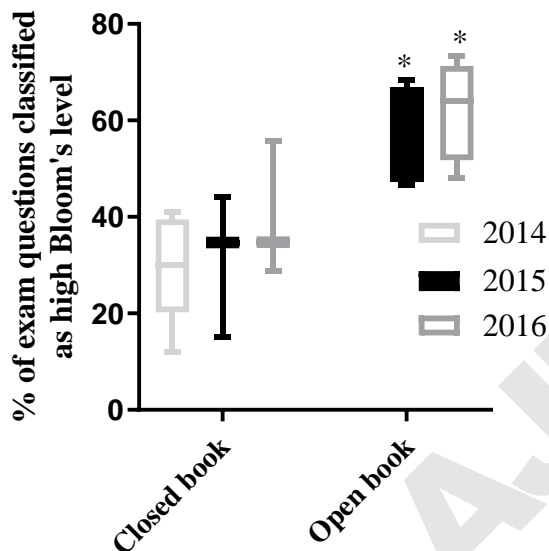
## REFERENCES

1. Eilertsen TV, Valdermo O. Open-book assessment: a contribution to improved learning? *Stud Educ Eval.* 2000;26(2):91-103.
2. Tussing L. A consideration of the open book examination. *Educ Psychol Meas.* 1951;11:597-602.
3. Stalnaker JM and Stalnaker RC. Open-book examinations. *J Higher Ed.* 1934;5(3):117-120.
4. Feller M. Open-book testing and education for the future. *Stud Educ Eval.* 1994;20(2):235-238.
5. Gharib A, Phillips W and Mathew N. Cheat sheet or open-book? a comparison of the effects of exam types on performance, retention, and anxiety. *Psychol Res.* 2012;2:469-478.
6. Williams JB and Wong A. The efficacy of final examinations: a comparative study of closed-book, invigilated exams and open-book, open-web exams. *Br J Educ Tech.* 2009;40(2):227-236.
7. Broyles IL, Cyr PR, Korsen N. Open book tests: assessment of academic learning in clerkships. *Med Teach.* 2005;27(5):456-462.
8. Densen P. Challenges and opportunities facing medical education. *Trans Am Clin Climatol Assoc.* 2011;122:48-58.
9. Ramamurthy S, Er HM, Nadarajah VD, Pook PCK. Study on the impact of open and closed book formative examinations on pharmacy students' performance, perception, and learning approach. *Curr Pharm Teach Learn.* 2016;8(3):364-374.
10. Heijne-Penninga M, Kuks JB, Schonrock-Adema J, Snijders TA, Cohen-Schotanus J. Open-book tests to complement assessment-programmes: analysis of open and closed-book tests. *Adv Health Sci Educ.* 2008;13(3):263-273.
11. Biggs JB, Kember D, Leung DYP. The revised two-factor study process questionnaire: R-SPQ-2F. *Br J Ed Psychol.* 2001;71(1):133-149.
12. Malczewska-Webb B, Nowacka M, Ong S. Research approaches and student surveys: a cross-cultural perspective. In: Gabryś-Barker D, Wojtaszek A, eds. *Studying Second Language Acquisition from a Qualitative Perspective.* Vol 27: Springer International Publishing; 2014:127-143.
13. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol.* 2006;3(2):77-101.
14. Anderson LW, Krathwohl DR, Airasian PW et al. *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* In L.W. Anderson & D.R. Krathwohl (Eds.) *The role of assessment in the revised taxonomy* (pp. 249–254). New York: Addison Wesley Longmann; 2001.
15. Bloom BS, Engelhart MD, Furst EJ, Hill WH and Krathwohl DRA. *Taxonomy of educational objectives: The classification of educational goals; Handbook I: Cognitive Domain.* New York: Longmans, Green; 1956.
16. White PJ, Larson I, Styles K et al.. Adopting an active learning approach to teaching in a research-intensive higher education context transformed staff teaching attitudes and behaviours. *High Educ Res Dev.* 2016;35(3):619-633.
17. Sato BK, He W, Warschauer M and Kadandale P. The grass isn't always greener: perceptions of and performance on open-note exams. *CBE Life Sci Educ.* 2015;14(2).
18. Heijne-Penninga M, Kuks JBM, Hofman WHA and Cohen-Schotanus J. Influences of deep learning, need for cognition and preparation time on open- and closed-book test performance. *Med Educ.* 2010;44(9):884-91.
19. Heijne-Penninga M, Kuks JBM, Hofman WHA, Cohen-Schotanus J. Influence of open- and closed-book tests on medical students' learning approaches. *Med Educ.* 2008;42(10):967-974.
20. Myyry L, Joutsenvirta T. Open-book, open-web online examinations: Developing examination practices to support university students' learning and self-efficacy. *Act Learn High Educ.* 2015;16(2):119-132.
21. Theophilides C, Koutselini M. Study Behavior in the Closed-Book and the Open-Book Examination: A Comparative Analysis. *Educ Res Eval.* 2000;6(4):379-393.
22. May W, Chung E-K, Elliott D, Fisher D. The relationship between medical students' learning approaches and performance on a summative high-stakes clinical performance examination. *Med Teach.* 2012;34(4):e236-e41.
23. Gregor A. Examination Anxiety: Live With It, Control It Or Make It Work For You? *Sch Psychol Int.* 2005;26(5):617-635.
24. Tavakol M, Dennick R. Making sense of Cronbach's alpha. *Int J Med Educ.* 2011;2:53-55.

Table 1. Examination Performance in First and Second Semester Courses (mean  $\pm$  S.E.M.)

Closed booked examinations (Semester 1)			Open book examinations (Semester 2)		
	2015	2016		2015	2016
Course 1	70 $\pm$ 1	72 $\pm$ 1	Course 4	67 $\pm$ 1	67 $\pm$ 1
Course 2	68 $\pm$ 1	67 $\pm$ 1	Course 5	68 $\pm$ 1	67 $\pm$ 1
Course 3	67 $\pm$ 1	69 $\pm$ 1	Course 6	62 $\pm$ 1	63 $\pm$ 1
			Course 7	89 $\pm$ 1	89 $\pm$ 1

Figure 1. The Percentage of Examination Questions Classified as High Blooms was Greater in Open Book (semester two) Examinations Where a Medicines Formulary was Allowed Compared to Closed Book (semester one) Examinations.



\* indicates  $p < .05$  compared to closed book examinations in the same year  
2014 is included for comparison only

Table 2. Cohort Age and Gender Demographics and Self-reported Hours of Study per Week of Students that Completed Surveys for Semester 1 and Semester 2 in 2015 and 2016 (Average age is expressed as mean  $\pm$  S.E.M.).

	2015		2016	
	Semester 1 (closed book examinations)	Semester 2 (open book examinations)	Semester 1 (closed book examinations)	Semester 2 (open book examinations)
Number of responses per enrolment	54/213 (25.4%)	49/227 (21.6%)	43/229 (18.8%)	34/231 (14.7%)
Average age	22.3 $\pm$ .2	22.5 $\pm$ .3	22.8 $\pm$ .3	22.9 $\pm$ .4
% Female	78	76	76	75
Hours of study per week				
Weeks 1-6 of semester	11.8 $\pm$ 1.4	10.0 $\pm$ 1.0	13.6 $\pm$ 1.7	12.9 $\pm$ 3.0
Weeks 7-12 of semester	17.0 $\pm$ 1.7	15.9 $\pm$ 1.3	17.5 $\pm$ 1.9	18.2 $\pm$ 3.3
Non-teaching week and examination period	40.4 $\pm$ 3.7	50.4 $\pm$ 4.7	44.7 $\pm$ 3.2	51.6 $\pm$ 4.5

Table 3. Self-reported Student Study Approach Means, based on a five-point Likert scale

		2015		2016	
		Mean $\pm$ S.E.M.	Cronbach alpha	Mean $\pm$ S.E.M.	Cronbach alpha
Deep Motive	Semester 1	3.0 $\pm$ .6	.8	3.0 $\pm$ .5	.8
	Semester 2	2.8 $\pm$ .5	.7	2.9 $\pm$ .6	.9
Deep Strategy	Semester 1	2.9 $\pm$ .5	.8	2.9 $\pm$ .5	.7
	Semester 2	2.8 $\pm$ .4	.6	2.7 $\pm$ .6	.8
Deep Approach	Semester 1	3.0 $\pm$ 1.0	.9	2.9 $\pm$ 1.0	.9
	Semester 2	2.8 $\pm$ .8	.8	2.8 $\pm$ 1.2	.9
Surface Motive	Semester 1	2.2 $\pm$ .5	.7	2.2 $\pm$ .6	.8
	Semester 2	2.2 $\pm$ .5	.7	2.4 $\pm$ .7	.8
Surface Strategy	Semester 1	2.9 $\pm$ .5	.6	2.8 $\pm$ .6	.8
	Semester 2	3.2 $\pm$ .5	.6	3.0 $\pm$ .6	.7
Surface Approach	Semester 1	2.6 $\pm$ 1.0	.8	2.5 $\pm$ 1.1	.9
	Semester 2	2.7 $\pm$ 0.9	.8	2.7 $\pm$ 1.2	.9

1 = This item is never or only rarely true of me,

2 = This item is sometimes true of me,

3 = This item is true of me about half the time,

4 = This item is frequently true of me,

5 = This item is always or almost always true of me.

2015: N = 50 for semester 1 (closed book examinations) and 44 for semester 2 (open book examinations),

2016: N = 35 for semester 1 (closed book examinations) and 13 for semester 2 (open book examinations)

Accepted Draft



Table 4. Student experiences of examinations (exams) and perceptions of studying with the AMH (N = 48 for semester 1 and 43 for semester 2). Self-reported examination experience means, based on a five-point Likert scale: 1 = Not at all, 2 = To a small extent, 3 = Somewhat, 4 = To a large extent, 5 = All the time. \* Indicates a significant difference compared with first semester of the same year (\* P < .05, \*\* P < .01). (2015: N = 50 for semester 1 and 44 for semester 2, 2016: N = 35 for semester 1 and 13 for semester 2). Cronbach alpha values were calculated when there was more than one statement per statement type.

Statement type	Statement	Closed book examinations (Semester 1)		Open book examinations (Semester 2)	
		2015	2016	2015	2016
Examination satisfaction	1. The exams were intellectually challenging	4.1	3.8	4.1	4.2
	2. The exams aligned well with the learning outcomes of the unit (course)	3.9	3.7	3.6	3.6
	3. The exam questions suited allowed me to demonstrate my knowledge (command) of the topic	3.6	3.5	3.5	3.9
	4. The format of the exam questions was relevant to pharmacy	3.7	3.5	3.6	4.0
	5. The exam questions were engaging	3.6	3.4	3.4	3.6
	Cronbach alpha	.7	.8	.6	.3
Open book exam preference	6. I prefer open book to closed book exams	3.1	3.0	3.3	3.5
	7. I prefer closed book exams to AMH allowed exams	-	-	2.2	2.6
	Cronbach alpha	-	-	.8	.6
Anxiety	8. I felt anxious about the exams during the semester	3.7	3.4	3.6	3.7
	9. I felt anxious about the exams just prior to taking them	3.9	3.8	3.9	4.2
	Cronbach alpha	.8	.8	.7	.8
Refer to AMH during study	10. During my study, I frequently referred to an Australian Medicines Handbook (AMH)	3.3	3.2	3.9**	4.4*
	11. Knowing that I will have access to the AMH during the exam allowed me to pay less attention to remembering specific facts	-	-	3.6	3.9
AMH examinations testing higher cognitive levels	12. Knowing that I will have access to the AMH during the exams allowed me to pay more attention to higher level skills such as analysis and evaluation	-	-	4.1	3.8
	Cronbach alpha	-	-	.3	.7

Table 5. Themes, Subthemes and Representative Quotes

Theme	Subtheme	Participant quotes
Exams	Negative aspects	“They do not allow me to show my full understanding”
	Positive aspects	“Case-study based questions were great and definitely challenged me in a real way that i felt was significant and relevant to pharmacy practice”
	Thoughts of exam content	“Case-study based questions were great and definitely challenged me in a real way that i felt was significant and relevant to pharmacy practice”
Study	Approaches to learning	“The only limit on studying is time. If I have less time, this means I have to compromise and learn/route (sic) learn information that I believe would be on the exam”
	Quantity and justification	“I study more during end of semester (near exam period) and during mid semester break” “Unfortunately, I spent most of the second half semester practicing on interview questions and applying for internship positions which is why I studied less” “Highly pressed for time this semester with 2 PEPs only a week apart”
Role of AMH	How AMH was used	“During semester I study by making summaries and in the exam period I re-read my summaries, read lecture notes and textbooks (including AMH) and do practice questions”
	Negative aspects	“The AMH deterred students from expressing what they knew but instead relayed information found in the AMH. Students who utilised the AMH were able to do better than those who simply memorised and studied the lecture material”
	Positive aspects	“The use of an AMH in the exam, I believe closely resembles actual practice as a pharmacist where there is a big focus on finding the information from the correct place rather than memorising and rote-learning” “During my rural placement I started to read my AMH for hours a night. (focusing on the introductory sections of each chapter). I feel like this was the best thing I have done to increase my pharmacy understanding”