

Development of an online pharmaceutical calculations learning module

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Abstract:

At Monash University prior to 2004, no formal mechanism existed in later years of the pharmacy course to review or re-assess pharmaceutical calculations. Competency in the area at registration was a concern. A flexibly delivered online module was developed which contained tutorials, and practice and assessment questions in a multiple-choice format. The module was initially introduced into the pre-registration year, then subsequently into each undergraduate year level. Students needed to achieve a score of at least 80% in the assessment to pass the module. Preliminary evaluation showed the module was well accepted by students. Negative aspects mostly related to students perceiving some topics as irrelevant, computer difficulties and degree of difficulty of the questions. The assessment component of the module now forms part of the assessment within each year level. The module requires students to be responsible for their own learning and imparts the principle of life-long learning early in their pharmacy career.

Keywords: *calculations, learning module, pharmacy, online*

Introduction

Optimising patient safety is paramount for pharmacists. Accurate and confident performance in pharmaceutical calculations is pivotal for dispensing the *right drug* to the *right patient* at the *right time* in the *right dose* and using the *correct dose-form*.

Pharmacy schools need to impart to students the knowledge and skills to perform pharmaceutical calculations throughout their tertiary education experience and beyond. Imparting this knowledge is generally made easier if students entering pharmacy courses have a robust understanding of numerical concepts and competent numeracy skills. However, research shows that students entering UK pharmacy courses over the last decade have decreasing numeracy skills (Malcolm & McCoy, 2007). Taylor and Bates (2004) have reported that the impact of decreasing numeracy skills is compounded by increasing pharmacy student intakes which permits students with lower numeracy skills to enter (Taylor, Bates, & Harding, 2004). However, anecdotal reports do not support that Australian pharmacy students have a decreasing ability to accurately perform basic calculations on entering their undergraduate degree.

The Monash University Bachelor of Pharmacy degree is a 4-year full-time program followed by a part-time pre-registration

(internship) course concurrent with one year of workplace-based training; successful completion of both is necessary for eligibility to sit pharmacy registration exams. At Monash University and most other Australian pharmacy schools, pharmaceutical calculations are not taught as a stand-alone unit. Through their association with many topics, pharmaceutical calculations are delivered in a fragmented manner via lectures, practical sessions and small group tutorials scattered throughout various units across different year levels.

Prior to 2004, once a specified component of pharmaceutical calculations was taught and examined at a particular year level no mechanism existed to formally review and re-assess these components in later years. Students were expected to apply their calculation skills – throughout the remaining undergraduate years, the pre-registration year and registration exam – with the skills potentially remaining unexamined and unreinforced subsequent to their initial teaching. Concerns were expressed at the faculty's Education Committee about students' ability to pass fourth year practical exams possibly without passing any of the calculation components. It was also noted that calculation problems were performed poorly by students during experiential placements, as witnessed in the third and fourth year placement workbooks.

It is important to note that in Australia demonstrating

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competency in pharmaceutical calculations in the pre-registration year is critical given the Australian Pharmacy Council's requirement for pharmaceutical calculations to be a core component of any pre-registration training program and the inclusion of pharmaceutical calculations in the registration exam (Australian Pharmacy Council, 2010).

It was clear that a better method was required to support pharmaceutical calculation education at our institution to ensure graduate competency following graduation and registration. Following an internal review and consultation with practicing and academic pharmacists, it was determined that a solution was required that would allow:

- coordinated sustained support of pharmaceutical calculation education across all year levels of the pharmacy undergraduate course and into the pre-registration year
- self-directed learning with a self-assessment component for students and an assessment module for examiners
- addition and deletion of materials as required
- flexible delivery of materials at a time and place suitable to users.

Module description

The module contents were based on those initially developed at our institution by Pappas et al (Pappas, Cesnik, Roller, & Sorgetti, 1998). This consisted of a computer-aided learning program delivered on CD-ROM to teach pharmaceutical calculations and upskill overseas-trained pharmacists for the Australian Pharmacy Examining Council (APEC) examinations. Although the module's psychometric properties were not formally assessed, face and content validity was considered to be acceptable as the materials were developed and reviewed by experienced practicing and academic

pharmacists, and because of prior positive evaluation of the module by APEC candidates (Pappas et al., 1998).

In 2004 we piloted the module (delivered on CD-ROM) in our pharmacy pre-registration course before further developing the module and adapting it for online delivery across all undergraduate year levels (Elliott, McDowell, Marriott, Calandra, & Duncan, 2008). Careful consideration was given to the existing undergraduate curriculum and the expectations of the registering authority and the profession for practice in community, hospital and industrial pharmacy settings. Topics were selected with input from the profession and the pharmacy registration authority. In all, 15 topics were developed and made available to students at various stages (Table I).

Topic-specific tutorials were developed giving background information and worked examples to reinforce the didactic and practical components of the undergraduate course. A series of practice (n=158) and assessment (n=152) questions were developed covering the range of topics identified and presented in a multiple-choice format; questions were separated such that those appearing in the practice assessments could not appear in the final assessments, and *vice versa*.

The module was delivered via WebCT (WebCT, USA), a web-based teaching and learning platform. It was structured into three main sections:

1. A tutorial section
2. Students could access the tutorials online; alternatively, hard copies were placed in the university library
3. Practice or self-assessment quizzes

Students were able to select topics and complete as many practice quizzes as required to become proficient with the topic area. Each topic contained sets of randomly generated questions relating to that topic; upon completion of the question set immediate feedback on performance, including worked solutions, were automatically provided.

Table I. Contents for online pharmaceutical calculations module

Topics	Year level				
	Undergraduate				Pre-registration
	1 st	2 nd	3 rd	4 th	
Units & conversions	x	x	x	x	x
Percentages & conversions	x	x	x	x	x
Density & specific gravity	x	x	x	x	x
Manipulating pharmaceutical formulations	x	x	x	x	x
Weighing & measuring	x	x	x	x	x
Dilution of liquid formulations	x	x	x	x	x
Dilution of solid & semi-solid formulations	x	x	x	x	x
Millimoles, milliosmoles	x	x	x	x	x
Iso-osmotic & isotonic solutions	x	x	x	x	x
Molecular manipulations	x	x	x	x	x
Posology	x	x	x	x	x
Body cavity delivery systems	x	x	x	x	
Buffer solutions	x	x	x	x	
Drug stability		x	x	x	
Clinical calculations			x	x	x

Assessment quizzes

The online assessment component consisted of 15 randomly generated questions covering the topics listed in Table I. The assessment component was structured to allow for variation in the degree of difficulty and number of questions allocated to each topic. During each year of the undergraduate and pre-registration courses students were required to successfully complete an assessment quiz. Each student was allowed two opportunities for completion, although only one was necessary if they were successful on the first attempt. Students could attempt the assessment from a location of their choice but were required to complete it by a specified date. Students were allowed one hour to complete the assessment; remaining time was displayed on screen and questions were presented one by one. After completion a final mark only was provided; answers or worked solutions were not provided. To pass the assessment a score of at least 80% (12 correct answers) was required. This pass mark was chosen based on the pass mark in the calculations component of the registering authority's registration examination and what academic staff considered a reasonable indicator of competence in pharmaceutical calculations.

The online version of the module was delivered in 2005 exclusively to pre-registrants. Delivery to four undergraduate years was rolled out over three years – initially to 3rd and 4th year students as nearly all lectures, practical sessions and small group tutorials in those years required negligible pharmaceutical calculation, then to 2nd year and finally to 1st year students; the majority of pharmaceutical calculation topics were taught in 1st year.

'Clinical calculations' was the only topic where questions were classified as 'easier' and 'harder'; 3rd year students received only the 'easier' questions, and 4th year students and pre-registrants received both. Questions considered 'harder', as assessed by a panel of academic and practicing clinical pharmacists, required greater clinical knowledge to perform and related to material taught in later years of the undergraduate curriculum.

Assessment quizzes delivered to 1st and 2nd year students contained at least one question from each available topic; assessments for 3rd and 4th year students and pre-registrants were weighted with an increased emphasis on clinical calculation questions, because from 3rd year the content would

be supported by clinical context as students undertook Clinical Pharmacy units containing strong clinical focus and placements in practical settings.

The assessment component of the module forms part of the assessment for the Pharmacy Practice units in all four years and the pre-registration year.

Evaluation

Preliminary evaluation data from the 2005 pre-registration year is presented; further evaluation across other year levels is underway.

In 2005, 110 pre-registrant students were asked to complete an online survey posted via WebCT after completing the module. The survey comprised a mixture of multiple-choice and free-text questions. Thirty-eight (35%) students responded, and their ranking of the module indicate that most found it helpful (Table II). The qualitative free-text component described positive and negative aspects of the module (Table III). Negative aspects mostly related to students perceiving some topics as irrelevant, computer difficulties and degree of difficulty. Interestingly, when asked for suggestions to improve the module, students overwhelmingly requested to have more of the same topics.

Future plans/work/implementation

To our knowledge this is the first report of a flexible delivery online pharmaceutical calculation module developed specifically for pharmacy students. The module has provided us with a flexible pathway to maintain and reinforce pharmaceutical calculations in a consistent and coordinated manner to both undergraduate students and pre-registrants.

The staged introduction of the module allowed it to be targeted initially to those perceived to be most in need of pharmaceutical calculation support (i.e. final year students, who had not received recent formal teaching and assessment of pharmaceutical calculations), while confining teething problems to a smaller group of users.

Based on the preliminary feedback from pre-registrants and anecdotal evidence from students in all year levels, the module is generally well accepted by students. The mandatory passing

Table II. Pre-registration ratings of pharmaceutical calculations online module*

Question	Mean (SD)
How would you rate the tutorials?	4.2 [†] (0.89)
How would you rate the practice quizzes?	4.3 [†] (0.74)
How helpful was the immediate assessment & feedback?	4.6 [†] (0.86)
After completing the calculations module I felt more confident about my calculations skills	4.0 [‡] (0.82)
After completing the calculations module I felt well prepared for the pharmacy registration examination	3.8 [‡] (0.94)

*Using a 5-point Likert scale

[†] where: 1 = not helpful at all, 5 = very helpful

[‡] where: 1 = strongly disagree, 5 = strongly agree

Table III. Pre-registrant comments about calculations module

What students liked about the module (number making comment)		
comprehensive (8)	a refresher (4)	simplicity (2)
good practice (7)	tutorials (3)	relevant (1)
worked answers (6)	availability of assessment and explanations (2)	online (1)
immediate feedback (6)		reason why I passed (1)
What students disliked about the module (number making comment)		
some questions irrelevant to current pharmacy practice or what would be examined (7)		tutorials too long (2)
some questions too easy (3)		not enough time (2)
same question repeated several times [when students repeated practice quizzes several times] (3)		need more questions (2)
difficult to calculate and do working out on a computer (2)		stressful (1)
some questions too hard (2)		needed a fast computer with internet access (1)
Topics deemed irrelevant in the module (number making comment)		
specific gravity (3)	milliequivalents (2)	molar mass (1)
temperature conversion (3)	osmolarity (2)	parts per million (1)
milliosmoles (3)	isotonicity (2)	conversion from w/v to v/v (1)
millimoles (2)		parenteral nutrition (1)

conditions on assessments encourage students to maintain minimum standards of numeracy until eligible for pharmacy registration. Importantly, this requires them to be responsible for their own learning early in their career and imparts the principle of life-long learning, a critical aspect of being a pharmacist.

Although predictive validity of this module was not formally assessed, feedback from the Pre-registration Course Stakeholder Advisory Group, which included practicing pharmacists and representatives from the pharmacy registration authority, were positive. The group indicated that the cohort of pre-registrants who was exposed to this module displayed improved calculation abilities after the introduction of the program compared to earlier cohorts who did not complete the module. Unfortunately, official pass rates for these exams are not made public. Further evaluation is required to confirm the reliability and validity of this module.

The online delivery has limitations – specifically the possibility of cheating, whereby students can obtain assistance to complete the assessments. However, cheating is minimised by having randomly generated assessment quizzes so each student's test is different and by warning students that evidence of collusion will result in immediate assessment failure. Passing the module was important to students, with failure to do so resulting in failure of the unit in which the module is contained. Cheating could be prevented by requiring all students to complete the online assessment under supervision – similar to a written examination – but this would significantly impact computer, staffing and timetabling resources.

The module's flexibility provides scope for future expansion and development, such as addition of new topics and questions with varying difficulty across year levels. The content of this module can be adapted or further refined by various pharmacy organisations and registration authorities to assess pharmacists'

competency in pharmaceutical calculations in accordance with the numeracy standards required by the organisations.

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