INSTRUCTIONAL DESIGN AND ASSESSMENT

A Simulated Learning Environment for Teaching Medicine Dispensing Skills

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Objective. To develop an authentic simulation of the professional practice dispensary context for students to develop their dispensing skills in a risk-free environment.
Design. A development team used an Agile software development method to create MyDispense, a web-based simulation. Modeled on virtual learning environments elements, the software employed widely available standards-based technologies to create a virtual community pharmacy environment.
Assessment. First-year pharmacy students who used the software in their tutorials, were, at the end of the second semester, surveyed on their prior dispensing experience and their perceptions of MyDispense as a tool to learn dispensing skills.
Conclusion. The dispensary simulation is an effective tool for helping students develop dispensing competency and knowledge in a safe environment.

Keywords: MyDispense, simulated learning environment, drug dispensing skills

INTRODUCTION

Medicine dispensing is a core skill and a key competency for pharmacists. As such, it is a major focus of pharmacy education in Australia and many other countries.[1] As a key competency, the development of medicine dispensing skills requires access to specific equipment, specialized information, and resources.[2] All Australian pharmacies use computers to record prescriptions and maintain patient dispensing history as part of the dispensing process. The model pharmacy/dispensary, specified until 2013 as a requirement for course accreditation in Australia,[3] was commonly used to simulate dispensing contexts and activities in universities. However, the model dispensary at Monash University was difficult to use for teaching large classes and proved too costly to operate in terms of space, staffing, provision, and maintenance of current medicine packaging. Furthermore, the model dispensary did not use computers as part of the dispensing process.

As a professional competency, dispensing blends specialist knowledge, functional and behavioral competence, and judgment, and is underpinned by appropriate ethics and values. Medicine dispensing is the integrated application of knowledge and cognitive proficiency, professional values and attitudes, technical and cognitive skills, reflection, and personal skills within a specific context.[4,5] The process of developing such competence occurs progressively by increasingly integrating separate dimensions during professional activities and decision making.[4] While pharmacy degrees can provide the knowledge and functional skills for the early stages of this competency development, as well as initiate development of the relevant ethical and professional values necessary for accurate dispensing, higher-level skills are usually acquired through continued professional practice following graduation.[6]

The challenge for many pharmacy education programs is to offer sufficiently rich and varied dispensing practice to undergraduates for successful transition to the clinical setting.[7] Most pharmacy degrees usually integrate experiential placements into the learning and teaching experience to offer learners the opportunity to develop their professional competencies and reflect upon their practice *in situ*, in professional contexts.[7-11] In the Monash bachelor of pharmacy (BPharm) program, these experiential placements are undertaken in the third and fourth years of the 4-year program.[12] To provide students with a variety of experiences, placement settings (experiential sites) include hospital, community, rural, and a limited number of international locations.

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Although all pharmacy degrees teach some aspects of dispensing, for many students with no experience working in a pharmacy, experiential sites are the first exposure to an actual practice setting and to the mechanics and responsibilities of dispensing medicines to patients. For pharmacy students with little practice experience, experiential sites are also the first opportunity to become familiar with pharmaceutical products: identifying package color, shape and branding, and beginning to interpret the dense information displayed on the package.[8] However, such practical experiential opportunities remain limited for reasons related to increasing demand and finite student support resources.[10]

The use of simulated learning and teaching environments offer a viable alternative for students to develop dispensing skills.[13] When carefully developed, such learning and teaching environments can provide students with basic skills within the safety of the simulated environment, which support students' successful transition from university to the clinical setting.[14,15] Moreover, simulated learning environments improve efficiency with large student numbers, enhance knowledge transfer to practical situations, and impact patient safety, all with a high degree of rigor.[14,16]

The use of a simulated environment changes the teaching method from direct instruction, or lecture, to that of productive failure, or a hybrid approach, in which students are able to directly experience the task and, as a result of frequency and format of feedback, are able to learn from their mistakes in a safe environment.[17,18] Dispensing errors in pharmacy are potentially life threatening. Thus, providing students with an opportunity to engage with the entire process in a supportive environment where they can receive explanatory and corrective feedback may improve learning.

Our research explored the design and development of one such environment called MyDispense. A dispensing simulation designed in the Faculty of Pharmacy and Pharmaceutical Sciences at Monash University, MyDispense provides learners with an authentic learning environment for developing their dispensing skills without the danger of negative health outcomes and consequences in real-world practice. The study was approved by Monash University's Human Research and Ethics Committee.

DESIGN

Monash University's 4-year BPharm is offered to large classes of around 200 students. Ranging in age from 18 to 22, students come from culturally diverse backgrounds.[12] Teaching within the degree is delivered across 4 streams (focus areas): enabling sciences, drug delivery, integrated therapeutics, and pharmacy practice. A strong emphasis is placed on face-to-face learning, and this is augmented with online experiential learning resources to facilitate independent learning.[12] These online resources include a virtual sterile clean room and tableting plant, medication familiarization, self-paced calculations tutorials, wikis for collaborative assessment activities, and MyDispense.

Prior to 2011, dispensing theory was traditionally taught in lectures, while the actual mechanics of dispensing was integrated into practical compounding classes. Students would hand-write labels, affix them to their newly made product, and hand them to their tutor (as their imaginary patient) while counseling them. No software was used to replicate the real-world experience, leaving students with a limited understanding of the real-life dispensing process and little appreciation of the inherent possibilities for error when dispensing electronically. Furthermore, these classes provided students with limited dispensing preparation prior to their third-year practice experiences. In 2011, MyDispense was introduced into the BPharm curriculum across 2 first-year pharmacy practice subjects.

MyDispense was designed as a simulated learning and teaching environment to help students develop skills and competency in dispensing medicinal products systematically, safely, and accurately at a level of detail and difficulty corresponding to their knowledge and experience. The focus of MyDispense is to help students develop accurate skills in dispensing a legally written prescription so the right patient receives the right prescription containing the right medicine (drug strength and route, and dosing frequency): the five Rs (right drug, right route, right time, right dose, right patient).[19] The software simulates the decision-making environment within which dispensing occurs without the reminders and prompts in commercial dispensing software and encourages students to learn by making mistakes, knowing they can fail in a safe learning environment.[17,20] MyDispense helps teach skills and the importance of discerning among products, various patient details and facts, while understanding the need to use unambiguous language on dispensing labels to clearly convey the prescriber's intentions.

Exercises in MyDispense are based on dispensing a prescription and can be designed to support specific tutorial outcomes, such as those involving product selection, controlled drug dispensing, and adding cautionary advisory labels. Two more tutorials, held at the end of each semester, are dedicated to revising the semester's learning. The absence of dispensing prompts and shortcuts commonly found in commercial dispensing software, such as Latin abbreviations, interaction information, similar

patient name alerts, and product storage tips, requires students to determine necessary actions at each stage.

The development team designed 108 exercises for year 1, semester 1 and 2 units. Modeled on typical community pharmacy dispensing scenarios, weekly exercises focused on variation within a single element of the dispensing process (see Table 1). Exercises required students to dispense basic uncomplicated prescriptions, as would be processed in a community pharmacy setting. For example, an error-free computer-generated prescription for a specific patient at a specific address, printed on a standard prescription template, requesting 20 amoxycillin 250 mg capsules tds (three times a day). The exercises were developed to authentically reflect tasks and challenges a community pharmacist would regularly face in the workplace.[21]

Apart from focus exercises during a tutorial week, all MyDispense exercises were structured to systematically integrate the relevant knowledge, critical thinking, technical activities, communication skills, and values necessary for developing dispensing skills. To support individual development, students received immediate feedback about accuracy and suggested improvements and had the ability to repeat activities, which encouraged development of beginner-level competency.

The software allows nonlinear navigation, requiring students to make conscious selections and judgments to progress through the exercise. Therefore, the sequence of processes necessary to dispense an item is not imposed within the software, but determined by the logic of dispensing itself. For example, a label may only be placed after the product has been selected. The discrimination required to progress through an exercise encourages self-regulation and awareness of the stages and skills employed at each stage of the process. Moreover, MyDispense subtly reinforces best-practice processes through the linear placement order of toolbar icons, which allow navigation to different areas of the dispensary, such as the dispensing software, the product selection room (the Backroom) reference materials, and the assembly bench for product labeling. This allows students to work through different components of the dispensing process, but the sequence of steps they choose to complete the task is individualized. That is, a student may select the product from the shelf before or after they generate a label.

Table 1. Exercise Variation from Week to Week during the Dispensary Simulation

Tutorial	Focus of MyDispense Exercises
1	Introduce the different elements of a prescription
2	Present many prescription templates from different prescribers (eg doctor, nurse, dentist)
3	Use drug and patient names easily confused with like-products or people
4	Explore elements of a label
5	Electronically record and review patient data

The development of MyDispense was a team effort. The original development team consisted of a project manager, two pharmacist consultants, an academic pharmacist consultant, two developers with database and web programming skills, and a graphic interface designer. In September 2010, a phased approach to software delivery was planned to rapidly deliver a functional program in a short timeframe. Version 1 was delivered 116 working days later, in March 2011; version 2 was delivered in August 2011 and version 3, in March 2012. Versions 1 and 2 delivered only aspects essential to the first-year curriculum while version 3 was a substantial refinement of versions 1 and 2, with the addition of a fact-finding component. Future versions with increased functionality are planned for later deployment.

The design process considered the simulation's need to reflect the real world (ie, the engineering–psychological fidelity balance). Engineering fidelity reflects the degree to which the simulated environment resembles real-world physical characteristics. Psychological (functional) fidelity describes the degree to which real-task skills are captured.[22] No strong educational requirement was determined for MyDispense to provide a 3D-immersive experience, so the psychological, rather than engineering fidelity, was optimized. As a result, software development systems that support 3D-environment creation, such as Second Life, Unity 3D and Adobe Flash, were ruled out, in favor of established web technologies.

To decrease staff–student engagement difficulties, the software structure was modeled on elements of typical virtual learning environments (VLEs) with which staff and students were familiar. The software featured: web-based access for use in the classroom and outside it; protection by an authentication system; ability to populate student and staff accounts via simple data files; a hierarchical structure of units, tutorials and exercises; various user roles such as student, instructor, marker, and administrator (to manage internal data such as patients, prescribers, and medicines and assessment); ability to group students for teaching and assessment purpose; facility to deliver assessments; and time-based release of tutorials and examinations.

Once design decisions were finalized, technical platform specifications were determined. To minimize compatibility issues and to future-proof the system against subsequent changes introduced from external software companies, proprietary plugin technologies were avoided.

The following up-to-date, widely available, open source and standards-based technologies were used: PHP for server-side coding; HTML & JavaScript for client side coding; CSS for styling; JQuery JavaScript library for graphic effects on the browser; JavaScript Object Notation (Json) for data interchange; Asynchronous JavaScript and XML (Ajax) for communication with the server that does not interrupt the current browser display; and cake PHP framework for rapid code creation.

Agile Software Development, a collection of development methods that allow incremental versions of a functional product to be rapidly created and then refined by user feedback, was used. This method facilitates collaborative and iterative software development. Fundamental design decisions were based on breaking down the dispensing process into logical components (eg, gathering information, producing a label, selecting a product) to provide discrete development elements. To guide development and document expectations from different users, the team developed "user stories" for all user types. User stories are sentences intended to capture nontechnical client requirements by having users describe an activity. User stories are in this format: As a <user type> I want <feature> so that <reason for feature>. For example: "As a staff user I want to be able to set the release date and time for examination exercises so I can control when students get access to examination exercises." When developed, the software was hosted on an Amazon Web Services (AWS) virtual server located in Amazon's Singapore Data Center.

The MyDispense software has 3 primary views: the student view, to deliver exercises and assessments; the administration interface, for teachers to build and manage exercises and assessments, to create student groups, and to manage students; and the exam manager to manage marking.

In the student view, students engage in the range of activities involved in dispensing medicines by completing exercises. Patient-centered exercises, authentic to a modern Australian community pharmacy, represent the process from receiving a prescription to handing the medicine to the patient. Exercises can be restricted to specific activity subsets consistent with the course curriculum and student proficiency. During exercises, students see virtual representations of patients, prescriptions, products on shelves, products for labeling, dispensary and ancillary labels, and note-taking tools. There are also web links to important, legally required pharmacy references. The software elements in the student view consist of the dispensary, the dispensing computer application where students retrieve and enter data, the product selection system where students retrieve medicines for dispensing, the medicines themselves, and patient and prescriber fact finding.

The "shop front" screen presents a first-person view of a pharmacist looking over the dispensary counter at a patient who has presented with their prescription, along with a computer and reference sources on a dispensing bench. The computer dispensing application allows prescription processing, patient information review, and dispensing label creation. It has high physical fidelity with interfaces typically seen in Australian pharmacies. This application, accessed via the desktop computer in the shop front, was designed following consultation with Australian pharmacy systems software companies. A notepad allows separate documentation of various notes: counseling points, notes to the tutor, and personal notes for later reference. The software was not designed to replace face-to-face counseling, but to allow students to virtually dispense a prescription before completing face-to-face counseling with the tutor or peer. This ensures students are able to experience the complete dispensing process, before going out on placement. A "backroom" screen contains shelves, a refrigerator, a controlled-drug safe for medicines selection, and a writable controlled-drug register for recording dispensing.

As accurate product selection is vital to dispensing, fairly high engineering fidelity was necessary to display products as they would typically be encountered in a pharmacy. After 4500 images were taken, a preview and thumbnail view was created of over 1000 individually photographed products. The medicine information selection field was populated with 1000 products using actual data donated by a commercial pharmacy software developer. A "bench top" screen allows scanning, prescription assembly, and manipulation of the generated dispensing and ancillary labels. Dispensing labels are attached to flat pack product images. A product verification scanner is included to verify product selections, as recommended in Australian pharmacies.[23]

Label generation and product selection are managed analogously to an online shopping cart: as virtual labels are generated and products selected, the associated number of inventory items increases. Items can be deleted as required. When an exercise is completed, feedback is accessible via an icon on the tutorial page. Immediate, rich contextual feedback on dispensing performance is provided to support best-practice learning. Automated individual feedback displays students' dispensing accuracy for selections that can be computer matched and, for fields where a range of inputs may be acceptable (such as wording of dispensing labels), students are provided with generic examples of best practice.

In the administrative interface view, exercises are constructed to individually connect a patient, a prescription, and

a medicine, for which feedback is then created. Then, the whole exercise is allocated to a tutorial. This interface also enables faculty members to group students for assessment and create assessable exercises. A database of more than 400 patient names is available with which to create prescriptions, supported by 135 male and female avatars of various ages linked to the name for visual representation. The database includes 30 characters from the internally developed curriculum-resource platform, Pharmville (Monash University, Melbourne, Australia), a fictitious community of people already familiar to Monash students.[24] When included in MyDispense exercises, the use of a familiar character reinforces the integration between subjects. This occurs as a Pharmville character, previously seen in perhaps a Chemistry course, may for example again be seen in a different discipline, that of pharmacy practice.[24]

The exam manager facilitates marking (grading) of assessments. Examinations are produced with automatically marked sections (eg, patient and product selection) and a manually graded section required to evaluate label instructions.

From March 2011, successive versions of MyDispense were rolled out in face-to-face tutorial settings in the Faculty of Pharmacy and Pharmaceutical Sciences up to version 3 in March 2012. Version 4 was available in a limited capacity. The tutorials formed part of the teaching activities of the 2 first-year units, Pharmacy, Health and Society 1 and 2. Ten tutorials sessions with multiple MyDispense exercises, delivered approximately every week during 2 semesters, were structured around teaching students an 8-step guide to safe dispensing.[25] As a result, technical elements and cognitive and personal skills were taught at each step. Demonstration exercises also using MyDispense were integrated into tutorials as supports for tutors to initially explain different concepts and for students to start practicing their skills while beginning to develop an understanding of the patterns that underpin best-practice dispensing.

Students independently worked through 5-10 exercises by the end of most tutorials. Exercises flexibly support students' first-year learning outcomes of retrieving, interpreting, and communicating basic medication information and applying it to pharmacy practice, dispensing simple medication dose forms, and developing critical-thinking and problem-solving skills. At the end of the semester, students took a dispensing examination on MyDispense, which contributed 10% toward their semester grade.

Exercises were designed and created by the two pharmacist consultants and members of the development team and integrated into the two Pharmacy, Health and Society units, in liaison with the subject coordinator. Implementing the software presented many challenges. The short development timeframe to version 1 required fast responses to unanticipated complications. Providing development solutions for managing unconsidered nuances of the dispensing process proved especially challenging. Similarly, the short timeframe allowed for only limited user testing and, in advance of tutorials occurring, it was impossible to fully load test the system. One of the initial challenges for developing exercises was developing content in advance of the software being ready. With the continual software refinement and adjustment using Agile methods, and without any visuals being available, it was difficult to conceptualize how exercises, especially the feedback, would practically function. Tutorials that include different screenshots of the software including those to which reference has been made are available on the MyDispense website (https://www.monash.edu/pharm/innovative-learning/technologies/my-dispense).

EVALUATION AND ASSESSMENT

Analysis of student performance on the final MyDispense examinations for the 2012 cohort showed a median student score of 98% for the unit PAC1311 (range 50-100%) and the unit PAC1322 (range 67-100%). At the beginning of the last tutorial in 2012, students were asked to anonymously complete a 38-question survey via the online learning management system. The survey, using Likert-scale type questions as well as questions seeking open-ended qualitative responses, focused on exploring the software's effectiveness in supporting learning about dispensing, utility of the interface and environment, and how students used feedback (Appendix 1). In addition to questions about MyDispense, students were asked to provide information on factors that possibly influenced their attitudes toward the software, including their age, language spoken at home, previous community pharmacy work experience, dispensing experience, and computer games exposure.

Preliminary survey data was collected on version 3 use by the 2012 first-year semester 2 student cohort (n=199). Only a minority of students regularly or frequently worked in a pharmacy (33%), and within this subgroup, 21% received no dispensing experience at work. Student responses to statements posed on the survey are presented in Table 2.

Responses to open-ended survey questions were thematically analyzed by two pharmacists (Table 3). Practically, the data was intended to guide further development of MyDispense. Pedagogically, it would be used to assess if MyDispense was able to support unit learning objectives related to introducing students to dispensing skills and knowledge and enhancing their understanding of

Table 2. Student Response to Statements about the MyDispense Simulation (n=199)

	%				
Statement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1. Using MyDispense helped me better understand the steps needed to dispense a prescription.	1.5	0.5	1.0	52.8	44.3
2. Attempting the tutorial exercises improved my confidence in dispensing prescriptions.	5.0	0.0	3.5	67.3	24.1
3. MyDispense is a stimulating learning environment.	8.0	1.0	6.5	67.3	17.1
4. MyDispense helped me learn from mistakes I made.	7.5	1.0	3.0	72.4	16.1
5. I used the feedback to change the way I worked through subsequent exercises.	3.5	0.0	3.5	58.8	34.2
6. The exercises prepared me to dispense prescriptions in the real world.	21.1	1.0	10.1	55.3	12.6
7. The feedback accessible to me at the end of the exercises was helpful for improving my understanding.	6.5	0.5	9.6	56.8	26.6
8. The exercises and assessment were consistent with the learning objectives of the unit(s).	9.6	0.0	3.0	67.8	20.1
9. I found the interface/environment realistic.	17.1	2.0	20.1	52.3	8.5

what it meant to be a pharmacy professional. Therefore, responses fell under headings broadly covering functionality, professionalism, elements of dispensing, and learning support.

When asked to list three things they had learned or better understood from using MyDispense (Question 1), students were able to identify aspects related to the process of dispensing (324 responses), medications (105 responses), professional enculturation (92 responses), and record keeping and references (58 responses). In response to identifying the best aspects of using MyDispense for learning dispensing (Question 2), students identified aspects related to professional enculturation (163 responses), learning support (116 responses) and design and functionality [of the program] (72 responses). Question 3 asked how MyDispense could be improved as a learning tool, and these responses overwhelmingly focused on performance and reliability (189 responses), followed by learning support (64 responses), design and functionality (42 responses), and other issues unrelated to MyDispense (10 responses). Typical responses to the best aspects of MyDispense regarded the students' improved understanding and confidence in dispensing, especially in a safe environment and the negative comments related mostly to the bugs in the software. Detailed feedback is provided in Appendix 2.

DISCUSSION

Teaching dispensing and its social and professional contexts is critical for all students in the undergraduate degree, as it cannot be assumed that students working in pharmacies will be receiving dispensing exposure, practice, or experience. This is consistent with US-based research that found students' previous work experience in a pharmacy did not improve their academic experience.[26]

Evaluation of MyDispense use and impact at Monash University shows the implementation was successful. The first-year tutorials using MyDispense were designed with the focus primarily on teaching basic dispensing steps and identification as a professional. The quantitative feedback shown in Table 3 about MyDispense showed the software supports these learning objectives, as student learnings and understandings (Question 1), and the best aspects, (Question 2), mostly related to professionalism and dispensing areas. Also, assessment of examination exercises showed students had formed a good understanding of the dispensing process and decision making. The examination questions required students to follow a clear process and make safe decisions, as in the tutorials, and the median student score for the MyDispense examination in the two units PAC1311 and PAC1322 being 98%. The learning objectives for the tutorials using MyDispense were closely aligned with the learning outcomes for the two units in which they were used, both heavily focused on developing basic professional pharmacy understanding. The exercises provided learners with scaffolding to integrate the cognitive and technical dimensions of dispensing competency development, while establishing professional values and responsibilities taught in the degree. In addition, during the ten 2-hour tutorials and in the 108 exercises, the use of computer simulation to replicate the dispensing process undertaken in community pharmacies allowed students to develop generic computer skills required for their career and was a major advance from the previous student experience where no exposure to dispensing software was gained during the course. This

Table 3. Results of the Thematic Analysis of Qualitative Comments from the Simulation Activity

Questions	%
1. List up to three things learned or understood better while using MyDispense (total no. comments=579)	
Professional enculturation	
a) The responsibilities, traits of, and issues for pharmacists	6.7
b) Concept of dispensing safely	6.0
c) Application of learning (cross unit connections)	3.1
Process of dispensing	
d) Dispensing steps	16.1
e) Prescription familiarity	8.3
f) Labeling products including placement or wording	23.0
g) Use of ancillary labels	8.6
Record keeping and references	
h) Patient medication record, recording, and information	5.2
i) Reference familiarity, the Pharmaceutical Benefits Scheme Medicines	4.8
j) Product and drug familiarity, including dosages	9.5
k) Product layout and storage	8.6
2. What were the best aspects of using MyDispense for learning dispensing? (total no. comments=351)	
Professional enculturation	
a) Learning the dispensing process; applying theory to practice in a safe environment	10.8
b) Prescription exposure (including a range of prescriptions)	3.1
c) Learn roles and behaviours of, and issues for, pharmacists	2.9
d) Practice and software preparedness (including patient management and interactions)	13.4
e) Realistic environment, characters, and scenarios	16.2
Learning support	
f) Experience in dispensing	18.0
g) Feedback allowing learning from mistakes	12.1
h) "Safe" dispensing without causing harm to patients	3.1
Design and functionality	
i) Easy to access and stimulating to use	3.1
j) Labeling – including wording and placement of labels and ancillary label selection	6.6
k) Online, virtual, interactive, experiential mode (better than lectures or tutorials)	3.1
l) Product and drug familiarity; their layout and storage	6.3
m) Reference familiarity and availability	1.4
3. How could MyDispense be improved as a learning tool? (total no. comments=305)	
Performance and reliability	
a) Fix development bugs (eg error messages, label placement errors, crashing, freezing)	33.1
b) Increase performance (eg, speed, movement between screens)	28.9
Design and functionality	
c) Make more similar to commercial software or replace with commercial software	3.6
d) Improve design	1.3
e) Increase realism (eg, add improved avatars, more products or give avatars a voice)	5.9
f) Improve user friendliness (eg, add software prompts or help, search capacity)	3.0
Learning support	
g) Include counseling	0.7
h) Develop exercise depth, number, or ability to repeat exercises	4.9
i) Make the dispensing sequence fixed, not free form	0.3
j) Develop feedback depth, amount, and accuracy	15.1
Unrelated to MyDispense	
k) Improve the tutorial organisation, delivery, or content	1.7
l) Include a nonvirtual dispensing option in the unit	1.0
m) Improve accessibility (eg, link to the content management system or log in)	0.7

intensive practice in a highly targeted virtual professional environment also helped develop students' professional skills and their awareness of professional competencies, necessary for practice.[27]

MyDispense was designed as decision-making software to help students commit to process points (eg, which label, what directions, which product). Counseling skills were outside this initial decision-making framework so a free-text panel was designed to allow students to document counseling points for patients.

Given the short lead time from planning to software implementation, it was unsurprising that most student recommendations for improvement were related to performance and functionality. Student comments were heavily relied on to prioritize onoing versions 2 and 3 developments, such as redesigning the feedback delivery and increasing the prominence of counseling to become a separate feature at the end of the dispensing process. Avatars with an improved design were also added to address some of the comments about lack of realism. The survey will be repeated to assess students' experiences with later versions of MyDispense.

The modular nature of MyDispense could allow its development in response to course and professional changes, as well as to new student groups, products, patients, and prescribers. As a result, MyDispense could deliver and manage any number of exercises and assessments. The exercises in MyDispense follow the Miller model of clinical competence, which suggests that students need to have a foundation of knowledge (Knows) and then develop experience (Knows How) so they are able to demonstrate (Shows How) and successfully complete (Does) the task.[28] The customizable and modular nature of MyDispense makes it a potentially useful tool for students to demonstrate they are capable, safe dispensers.

The focus of MyDispense has intentionally been on community pharmacy. Inpatient (hospital) practices (ie, products, prescriptions, and inpatient dispensing procedures) are substantially different to those in community pharmacy practice, and they have not been incorporated into MyDispense. However, limited aspects of hospital practice can be introduced through patients presenting discharge prescriptions to the community pharmacy.

One of the primary challenges in developing this simulated learning experience, realized during the software planning phase, was logically compartmentalizing the dispensing process. This proved difficult because of the highly situation-dependent nature of dispensing and the many grey areas of decision-making. Exploring the dispensing context at different stages through the use of user stories proved invaluable to the developers in understanding the pharmacists' nuanced role.

Early in the development process, it was decided that error checking and the user support normally found in commercial systems (ie, conversion of Latin abbreviations to modern directions and drug interaction checking)[29] would be designed out of the software to ensure students learned to consciously work through every aspect of the dispensing process rather than rely on embedded reminders to translate information and identify potential problems. Errors in any pharmacy environment can have devastating health consequences and are perceived by the profession to be increasing.[30] By exposing learners to a dispensing process with no prompts or automated checks, MyDispense obligated students to use available reference materials, thereby gaining an understanding of how to effectively use resources and consolidate their knowledge of contraindications and drug interactions.

The ability to create near limitless scenarios in MyDispense, as well as using similar or repeated combinations of patient names, addresses, and products, provided possibilities for the novice student to make dispensing errors and then learn from the explanatory and corrective feedback provided.[18] Immediate feedback for every exercise attempt highlighted whether students were successful or not in their data entry (eg, patient selection, drug selection, date) and allowed them to see examples of well-phrased label instructions. This, combined with the ability to reset exercises, helped students apply new learning to later exercises. Immediate feedback and the capacity to repeat the task or proceed to a new task allowed the learner to engage with the feedback, and this process aligned with recognized best practice in teaching.[31]

Adopting an Agile Software Development strategy for MyDispense relied on regular team meetings to address issues and set new short-term goals, which allowed software development to react creatively to developer and user feedback. For example, user interface adjustments along the way made the student dashboard more user friendly and a reset feature was added to allow students to re-attempt exercises, allowing for additional practice or revision.

SUMMARY

My Dispense adopts many of the best-practice measures identified for simulation-based education (feedback, deliberate practice, curriculum integration, outcome measurement, simulation fidelity, skill acquisition and maintenance).[15] The "no consequence" nature of the software ensures students can fully explore the dispensing process in a safe environment before they commenced placements.

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Appendix 1. MyDispense Student Survey

About Me

1. Male / Female
2. The language I use in my home is:_____
3. Age: _____
4. I am a domestic / an international student
5. Circle the option that best represents your experience on average:
   a) I have worked or work in a community pharmacy: never | rarely | regularly | frequently
   b) I have used commercial dispensing software: never | rarely | monthly | weekly or more
   c) I use Facebook/Twitter/on-line chat: never | rarely | monthly | weekly or more

About MyDispense

6. List the units in which you have used MyDispense: PAC_____ , PAC_____
7. How many times have you used MyDispense in units _____ in your own time? _____
8. List up to three things that you learned or understood better while using MyDispense?

[For 9-35] Circle *ONE* number between 1 and 5 in each of the following statements to describe **your experience of the MyDispense software tutorial exercises and or assessment**. [1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree]

9. Using MyDispense helped me better understand the steps needed to dispense a prescription.
10. Attempting the tutorial exercises has improved my confidence in dispensing prescriptions.
11. I am better at dispensing prescriptions from having attempted the tutorial exercises in MyDispense.
12. MyDispense is a stimulating learning environment.
13. The exercises have prepared me to dispense prescriptions in the real world.
14. I understood what was required of me at each stage of the MyDispense activities.
15. I used the feedback to change the way I worked through subsequent exercises.
16. The feedback accessible to me at the end of the exercises was helpful for improving my understanding.
17. There was sufficient feedback to help me improve.
18. Exporting the feedback, for example, as PDF, would help my learning.
19. The exercises and assessment were consistent with the learning objectives of the unit(s).
20. Logging in and accessing MyDispense was easy.
21. MyDispense helped me learn from mistakes I made.
22. Being unable to re-attempt exercises made the experience more realistic.
23. I have regularly cancelled exercises and restarted them in order to improve the accuracy of my dispensing.
24. When attempting exercises, I made use of resources on the MyDispense screen.
25. The patient and prescription information is easy to refer to.
26. I was able to dispense in a sequence of my choosing.
27. I followed the steps in the *MyDispense Guide to Dispensing.*
28. I found the *MyDispense Student User Guide* on Blackboard useful
29. The tutorial class work was reinforced by activities in MyDispense
30. The tutorial activities and the MyDispense exercises were well aligned
31. Overall there was sufficient guidance on how to use MyDispense
32. I felt confused about what to do next
33. I found the interface/environment realistic
34. I was able to move between the various screens with ease
35. The interface design is pleasing
36. What were the best aspects of using MyDispense for learning dispensing?_____
37. How could MyDispense be improved as a learning tool?_____
38. If you used the MyDispense software **at home**:

Computer type:
PC
Mac
My internet connection is:
Broadband/ADSL
Dial-up
Wireless
3G
Browser:
Internet Explorer ____ (list version)
Firefox
Chrome
Safari
Speed and responsiveness of the program:
Excellent
OK
Slow or lagging

Appendix 2. Specific Detailed Feedback on MyDispense

On understanding of dispensing a prescription and receiving feedback:

. . .the fact that I was expected to dispense medication exactly the same way as would be expected in the real world. This I found to be extremely helpful and the fact that I can make a mistake and have feedback telling me what it was helped reinforce many aspects of dispensing which I could have missed out on or did not deem to be important, but through this program I realized that it is.

It provided a simulated, but real, experience to dispensing medications especially for someone (like myself) who has never had any practical experience in pharmacy and dispensing medications. I personally have never seemed to find any appeal in community pharmacy but through MyDispense, I have learned many new things I would have otherwise not have known.

The stimulated environment was very similar to that of a real pharmacy. I work in a pharmacy, and the layout of the fridge, dispensary and even the drugs of addiction book were so realistic, which made the experience more accurate and will hence improve our understanding when we enter the real world of dispensing. The script types and drugs we were exposed to were also great. The actual pictures of the drugs in the fridge and dispensary were impressive! The program overall helped me better understand the dispensing process.

On learning in a safe environment:

MyDispense is good because it gives us the experience and practice of realistic dispensing without having to place any risk on real patients in our community.

. . .being able to practice dispensing without there being consequences if you got something wrong.

On developing confidence in dispensing a prescription:

It helps me know the steps in dispensing, and having the feel and practice of dispensing (for a person who is not working in a pharmacy yet).

It was useful and helped me when it came to dispensing in a community pharmacy as it allowed me to practise dispensing in an environment that was not as stressful as a community pharmacy.

On being able to learning from my mistakes:

There are a number of areas where realistic mistakes could be made (selecting from a long list of drugs with similar names/ dosage/packaging) which helps prepare for real dispensing.

Being able to dispense medications in a virtual environment and learn from my mistakes to avoid doing this in the real world environment.

On recommended improvements:

Increase the speed; Prevent it from suddenly shutting off, hence have to restart all over again; Provide accurate feedback; Provide more descriptive feedback

Make the interface better. Make it more responsive. The server errors are far too frequent and it's not very accurate in detecting our responses at times, especially when labelling. The server tends to overload quite easily as well.