

Final Report 2011

Development of a computer-generated digital patient for teaching and assessment in pharmacy

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Software is available at:

<http://resweb.newcastle.edu.au/VirtualPatient/private/uploads/>

Username and passwords can be requested from david.newby@newcastle.edu.au

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1. Executive summary

Communication skills are important to all health professionals. They are especially important to pharmacists fulfilling their primary healthcare role, as they are often reliant on obtaining a good oral history to manage minor illnesses. A significant amount of time in university pharmacy programs is devoted to teaching these skills. However, students have limited opportunities to practise these skills and to obtain feedback. To address this problem the project team developed and tested a computer-generated virtual patient for pharmacy students to practise and improve their communication, diagnostic and management skills for minor illnesses.

The project was divided broadly into two phases: the software development phase and the evaluation phase. The software development was further divided into development of the imaging and voice; and the development of the reasoning algorithm, assessment and feedback modules, and the reporting and administration modules. The software used a three-dimensional model that could display facial expressions and used text-to-speech to provide responses. The most complex element was the reasoning algorithm that had to 'understand' the students' questions and then provide an appropriate response. As there was no existing ontology, sophisticated artificial intelligence could not be used and the team had to work 'from scratch' to develop the reasoning algorithm. This involved a number of iterations, including having students attempt to come up with different ways of asking a question, and using the unmatched questions (questions the software could not match to a response in its database) in early testing to further develop the database. The final software captures the questions asked and answers given in the students' interaction with the patient, as well as the students' chosen diagnosis and management. As feedback, the software provides the student with a summary of the questions they asked and the rationale for asking them, the questions they did not ask, the correct diagnosis, and the correct evidence-based management. Students can print these reports or download them, and then reflect on their own performance.

We evaluated the software in a trial involving 67 final-year pharmacy students across the three partner universities (The University of Newcastle, Charles Sturt University and Monash University). In addition to their regular lectures and tutorials, the students were randomly assigned to receive either three sessions with the virtual patient or no virtual patient sessions. Outcomes were changes in self-reported confidence, performance in managing minor illnesses as measured in an Objective Structured Clinical Evaluation (OSCE), and opinions about the software gathered by survey and focus group discussions. The two groups were generally similar at baseline in terms of demographics and self-reported confidence in communication skills. After using the software, students tended to be more positive about their confidence in their communication skills; however, the small number of responses made any differences difficult to interpret. There was only a limited impact on the students' performance in the OSCE, with no significant differences between the groups in their overall OSCE scores, their scores for communication skills, and the number of questions they asked. However, students who used the software appeared to be more likely to ask 'generic' questions, i.e. questions that should be asked irrespective of the potential diagnosis, such as whether the patient had allergies or if they could be pregnant. Students who used the software were generally positive about their experiences, despite some frustrations with the software not understanding some questions and the program running slowly at some sites. International students tended to be less positive about the software compared to domestic students, and this could be due to language difficulties. Students in Newcastle, where the software operated the best, were more positive than the other sites. The students indicated that they felt the software helped them with learning what questions to ask, to have a more 'systematic' approach to their questioning, and they really appreciated the feedback provided. The software was particularly useful for students who do not work in a pharmacy and therefore do not have



the opportunity to practise their skills, and the students felt the experience could be useful earlier in their training. This project has shown that the virtual patient has a useful role to play in pharmacy education, a view reinforced by those pharmacy academics who used the software as part of a workshop. Further, the software has been designed to be adaptable to a range of other settings and disciplines. This gives the virtual patient system the potential to be used in most health disciplines where structured questioning is important. However, it was also identified that the software requires further refinement to improve the question recognition and voice, and is very dependent on the hardware and operating systems on which it is run. The project could be used in its current form. However, rapid changes in technology mean that, for the software to have long-term utility, it may need ongoing support and funding. Users of the system could modify and support the program at their own expense or a fee could be charged, either up-front or annually, for ongoing access to updates of the software.



2. Project outcomes and impacts

2.1. Background

Pharmacists practise in a range of clinical settings. However, the majority of pharmacists work in private practice in the community where they play a pivotal role in delivering primary health care for patients with a range of minor illnesses. A significant part of the emphasis of education in undergraduate and graduate pharmacy programs is devoted to developing the clinical skills required to fulfil this primary health care role. These include communication skills, e.g. history-taking; diagnosing and differentiating minor illnesses from those that require referral to a medical practitioner; choosing the most appropriate treatment for these minor illnesses; and counselling on the correct use of the suggested treatment. These are especially important skills in the community setting where the pharmacist is usually solely reliant on an oral history to make the diagnosis on which to base their subsequent recommendation for treatment. Pharmacists are not able to physically 'examine' patients as doctors can, except for symptoms in clear view such as wounds or rashes, and they do not have access to other diagnostic tools such as blood tests, X-rays or CAT scans to confirm their findings. Fortunately, over 75 per cent of minor illnesses can be identified using an oral history alone (Rutter & Newby, 2007).

Communication and diagnostic skills are currently taught to pharmacy students using traditional lectures and tutorials, supplemented by practical experience gained during experiential placements in community pharmacies, hospitals and other pharmacy sites. The skills are generally assessed using written examinations or Objective Structured Clinical Examinations (OSCEs) with 'simulated' live patients (people trained to respond like patients). Current teaching and assessment methods are limited in their effectiveness:

- tutorials are not conducted using 'real' or 'simulated' live patients because of the large number of students in pharmacy programs
- there is a lack of adequate numbers of suitably trained 'simulated' patients for use in either tutorials, practise situations or assessments
- the costs of training and employing real or 'simulated' live patients is prohibitive
- real or 'simulated' live patients may not always provide a standardised response to a student question
- the clinical scenarios used in traditional tutorials have an artificial linear approach to problem solving, not allowing students to explore questioning in a narrative way
- clinical placements provide only a limited opportunity for students to practise their skills
- there is no control over the number and types of patients that students may encounter on placement
- feedback on students' interactions with patients on placement may be inconsistent and depend on their supervisor
- OSCEs are costly and time-consuming to develop and implement, and
- simulated 'live' patients must respond in a consistent way when used for teaching and examinations.

The project aimed to address these problems using a computer-generated simulated patient.



2.2. Project outcomes

The original project outcomes were described as follows:

'...the development and testing of a realistic computer-generated patient for assisting pharmacy students to practise communication, diagnostic and clinical skills in managing minor illnesses. The software will have potential application across any discipline where interviewing skills are required.'

Initially the project involved developing a computer-generated patient with the following attributes:

- simulates a real patient using a three-dimensional model to which various human characteristics may be added, such as skin rashes, body manoeuvres, eye contact and vocal responses
- captures both the questions asked by students, and answers given to the questions by the patient, in sequence
- provides feedback to students on whether they failed to ask certain questions
- provides feedback to students on whether they used appropriate questioning, e.g. open-ended versus closed questions
- analyses whether students asked irrelevant questions
- uses the questions asked by the student to prompt emotional responses in the virtual patient
- records the diagnosis and the chosen management for the patient, and
- presents the correct diagnosis and the current evidence-based recommendations for treatment.

All of these features were included in the development of the software. However, owing to unexpected difficulties in creating the computer-generated 3D patient, some features were not fully implemented in the final evaluation. For example, although the software has a range of emotional responses, only a limited number were used in the final evaluation version. In addition to the features above, it was decided to extend the development so that the software could support assessment in multi-disciplinary fields, i.e. it was expandable beyond the pharmacy teaching setting.

2.3. Methodology

The project was divided into two phases:

- software development (24 months)
- evaluation of the software (6 months).

The IT team comprised Professor Jesse Jin, Dr Richard Xu, Dr Mira Park, Dr Peter Summons, and Dr Rukshan Athauda.

The clinical team comprised Dr David Newby, Dr Jennifer Schneider, Dr Sheree Kable, Associate Professor Jennifer Marriott, Mr Gregory Duncan, and Associate Professor Maree Simpson.



Members contributed as follows:

Table 2.1: Project team member contributions

Software development: Imaging module Speech module	Prof. Jesse Jin (Leader) Dr Richard Xu Dr Mira Park
Software development: Reasoning algorithm Tutorial Student assessment/feedback Administration module Reporting module	Dr Peter Summons (Leader) Dr Rukshan Athauda Dr Mira Park
Evaluation phase: Development of clinical scenarios and management algorithms for software Obtaining ethics approval of evaluation phase Design of evaluation methodology and instruments Conducting evaluation sessions	Dr David Newby (Leader) Dr Jennifer Schneider Dr Sheree Kable A/Prof. Jennifer Marriott Mr Gregory Duncan A/Prof. Maree Simpson

Additional software programmers were Dr Peter Shaw, Dr Ilung Pranata and Dr Keping Zhang.

It should be noted the teams did not work in isolation, with input from the evaluation teams into software development to ensure the product was suitable, and from the software development team into the evaluation process to ensure appropriate assessment was conducted.

2.3.1. Project management

The entire project team met face-to-face on two occasions throughout the project. In addition, the leaders of each phase of the project held meetings, either face-to-face or by teleconference using Skype, to coordinate the activities of each phase.

2.3.2. Project reference committee

It was decided at the first project meeting to establish a reference committee for the project. The role of the reference committee was to provide input into the software development and the evaluation phase, and to help with the possible dissemination of the software. The terms of reference are attached in Appendix 1.

Composition of the reference committee

The composition was as follows:

Table 2.2: Reference committee membership

Member	Representing
<i>Ms Melanie Harrison</i> President of Newcastle University Master of Pharmacy Students association (NuMoPs)	Student representative
<i>Dr Kylie Williams</i> Pharmacy Department, The University of Sydney	Pharmacy Practice academic



<i>Associate Professor Gabrielle Cooper</i> University of Canberra	Committee of the Heads of Pharmacy Schools of Australia and New Zealand
<i>Mr Daniel Conway</i> The University of Newcastle	University IT department
<i>Ms Dani Amato</i> Pharmacist Education Officer, Pharmacy Board of South Australia	The Australian Pharmacy Council
<i>Professor Allyson Holbrook</i> Director, Centre for the Study of Research Training and Impact (SORTI), School of Education, The University of Newcastle	Academic with expertise in Learning and Teaching
<i>Professor Ernest Edmonds</i> University of Technology Sydney	Information System academic
<i>Ms Jaclyn Baker</i> Manager Professional Development, Pharmaceutical Society of Australia (Victoria branch)	Pharmacy profession
<i>Dr Sue Outram</i> Lead, Discipline of Health Behaviour Sciences, Faculty of Health, The University of Newcastle	Medical profession with an interest in medical education
Not filled	Nursing

Meetings

The reference committee met twice, in February 2009 and October 2009. Members in Newcastle met face-to-face with others joining by teleconference. Despite repeated attempts, we were unable to establish a suitable time for all members to attend. There were two changes in membership over the life of the project.

Output from the committee

The reference committee played an important role in shaping both the software development and the evaluation phase. Changes implemented in response to the input from the reference committee included:

- have the software provide feedback to the student on all areas of communication after interaction with the virtual patient
- provide an option on the software to print/save a copy of the feedback for future reference
- have the software capture the timing of each session to analyse whether students had a serious attempt with the virtual patient
- the inclusion of extra demographic information in the surveys used in the evaluation phase to look at differences between domestic and overseas students, and
- include additional questions in the evaluation questionnaires examining the impacts on confidence and the acceptability of using the virtual patient.

2.4. Software development

2.4.1. Previous virtual patient systems

Existing literature supports the educational advantages of employing actors as simulated



patients for both tutorial practice sessions and for assessments such as oral examinations, with significant improvements recorded in students' communication and history-taking skills (Tamblyn et al., 2007; Wind, van Dalen, Muijtjens, & Rethans, 2004). This was true even if there was no direct perception of the simulated patient as being human, that is, when the patient was 'virtual'. Orr reported significant increases in the students' "...knowledge, problem-solving, communication, and professional skills" when pharmacy faculty members took on role-playing positions as 'virtual' patients who provided responses to students via email in an early pharmacy assessment system (Orr, 2007).

Currently available computerised simulations of patients in medicine, dentistry, pharmacy, or nursing personalise the experience by employing images that are either static pictures of real patients or dynamic three-dimensional images – either video images of real patients or computer-generated images using virtual reality technology and avatars to represent patients.

Computerised virtual patient systems have been developed where a computer is used to present case studies to students and also provide feedback to the students. An early automated virtual patient system was developed for pharmacy student assessment at Monash University (Marriott, 2007). This was based on a prescriptive framework with an interface that teachers used to generate many case studies for assessment. The Web-SP virtual patient system (Zary, Johnson, Boberg, & Fors, 2006) employed static pictures of patients. It had a similar design aim to the Monash system, to develop a framework that allowed the scalable generation of new medical scenarios in domains such as medicine, pharmacy and dentistry. The Web-SP system's advantage was that its interface permitted questioning by a student and thus opened a more dynamic engagement of the student with the virtual patient. Both systems had efficiencies for teachers in terms of their preparation, administration and reporting of assessments, and for the provision of a large test bank of patients for assessment. They allowed individualised assessment scenarios to be generated for students, thus minimising plagiarism, and could report results for large numbers of students over a reasonable range of criteria. However, both also had limitations: Web-SP only allowed pre-formulated questions and provided a generic framework for domain teachers to use to generate the content of the questions. The Monash system was quite static, with student interaction limited to reading pre-set case study notes and then devising their own options for diagnosis and suggested medication and treatment. This pre-set case history did not allow any dynamic interaction in terms of a student's ability to investigate and explore patient history.

Other systems have encouraged student interaction and realism by providing video clips as responses to student questions (Bergin & Fors, 2003; Farrar, 2002). Video images allow system responses from the virtual patient to convey emotional aspects, such as pain or frustration, in addition to the textual content provided by systems using static images. However, a drawback of using video clips of real people is that, initially, they must be filmed and it is very time-consuming to provide appropriate video sequences for every possible patient response. It is also difficult to change features such as age, race and gender without involving a complete remake of the video.

Dynamic interaction has been achieved using virtual reality avatars, which are computer-generated animations used as representations of patients (Cavazza & Simo, 2003). These avatars typically do not have detailed human features but they allow easy modification of the virtual patient's appearance. They can also allow physical gestures and limited emotional expressiveness to be incorporated into the virtual patient.

One of the best examples of an avatar-based virtual patient operating within a virtual reality world was the DIgital ANimated Avatar (DIANA), created by the University of



Florida. DIANA is a female virtual character who played the role of a patient with appendicitis, while the virtual interactive character (VIC), a male virtual character, played the role of an observing expert (Lok et al., 2006). Students interacted with a life-size projection of the DIANA avatar using voice recognition technology.

A similar system has been developed by researchers in conjunction with the pharmacy program at Keele University in the United Kingdom (Connelly, 2008; Keele University, 2007), which is building four avatars for Monash University as part of its ePharm program. Although no published information exists for the Keele project, it was demonstrated recently (July 2009) at the Monash Pharmacy Education Symposium in Prato, Italy. The headset worn by the student for speech recognition has the capability to monitor some student characteristics, such as their head movement. This has the potential to track non-vocal assessment items that are important in interpersonal communication and patient questioning, such as student eye contact with the patient. However, evaluation of the DIANA virtual patient, and the demonstration of the Keele virtual patient, has identified the following limitations of these types of model:

- students felt the avatar needed more 'emotion' and needed to be more 'expressive' (Lok et al., 2006);
- only 60 per cent of student questions were recognised by the virtual patient (Stevens et al., 2006);
- there was difficulty with the speech recognition technology and students had to train before the assessment to increase the recognition capability of the system. These difficulties "...brought the students out of the relationship [with the virtual patient] and made them cognizant of the product rather than the process" (Lok et al., 2006).

The technical difficulty with accurate and consistent speech recognition may detract from students' learning experiences, as they may become frustrated and focus on problems caused by the system's inability to correctly interpret and understand their questions, rather than those caused by the wrong type of questioning.

Despite the limitations of the technology, there are many advantages in using computerised virtual patients rather than actors. These include savings in the cost and time of training, and the cost of employing real actors. Advantages are also realised in the standardisation of the assessment, with greater control over the assessment process and greater consistency of student feedback than is possible using real actors. Computerised virtual patients are available at any time and can be used for many assessments occurring simultaneously at many different locations. They can also easily record student performance and generate reports on individual students or the entire class, and can provide results for both summative and formative assessments.

2.4.2. Pilot phase: Virtual patient design

The design of the software for the current virtual patient was influenced by these previous virtual patient systems. As this was to be a pilot implementation of the virtual patient system, the software was developed with a simplified structure in order to increase its efficacy and avoid major impediments to the project delivery.

A free-text style of student questioning was adopted. This has potential problems for question recognition by the virtual patient but it allows students to express questions naturally, using their own language style. The students' questions were posed to the virtual patient using typewritten text rather than speech recognition. This allowed multiple students to use the software in the same room without disrupting each other. It also avoided the problems of misinterpretation of questions and the requirement for speech training in current speech recognition systems.



The virtual patient provided spoken responses for a greater level of realism. Male and female voices from commercially available speech engines were to be used. Individual headphones for virtual patient speech output were used at each student computer to enable many students to do the assessment simultaneously in the same room without disruption to other students.

The pilot virtual patient was equipped with limited facial expressions. The model used for the virtual patient is capable of facial expressions by providing different mouth movements, e.g. smiling, laughing. Even though the model has the potential capacity to provide 12 different mouth movements, only two, a smile and a plain expression, were implemented in the pilot virtual patient. A new mouth expression takes an average of two months to generate and incorporate into the virtual patient model.

The initial design of the software attempted to provide speech recognition of free-text student questions that was at least equal to current systems such as DIANA (60 per cent correct recognition of student questions). Initially this was to be based on simple data matching, with later refinements that included keyword matching techniques and the incorporation of a learning algorithm. There was no lexicon available for analysis of free-text student questions, no predefined or predictable sequence to the student questioning, and no training data available in sufficient quantity to employ sophisticated artificial intelligence (AI) recognition techniques, such as the use of a Neural Net. However, the software included a tool that would build a lexicon of student questions that could be used as a source for more advanced speech recognition techniques in later research.

The virtual patient was only able to respond to single-purpose questions, as multi-faceted questions would require sophisticated lexical analysis techniques to determine that there was more than one question to be matched. Similarly, students were limited to asking investigative questions rather than providing treatment advice. Separate input areas were included in the student assessment interface that allowed entry and modification of diagnosis and recommended treatment by the student at any stage during the assessment. A spell-checking facility was also provided to enhance the ability of the virtual patient to recognise the students' questions.

The use of a simple data-matching technique meant that the virtual patient prototype's effectiveness depended on the extent of the lexicon it used to match a student question. However, the lexicon will grow with use, and the efficiency of the system as an assessment tool will grow if more assessment scenarios are added by domain experts to provide more varied assessment in future. This flexible and easily scalable interface simplifies the generation of new patient scenarios within the pharmacy discipline and also means the software could be easily adapted and re-used in other disciplines.

For the pilot study, a server-based architecture was adopted for the prototype virtual patient. Microsoft SQL Server 2005 was used as a central database to store data (student logins, student questions input during assessment, assessment results, and the data required for the reasoning logic). The virtual patient program was written in Java (using NetBeans IDE) and some data required by the reasoning logic were ported to the client to speed up processing. The operating system to be used for the implementation was initially Windows XP. However, different versions of the prototype virtual patient system needed to be developed to accommodate changing hardware, networks and operating systems. Versions for Windows XP and Windows 7 were developed, as well as versions for SQL Server 2005 and 2008.



2.4.3. Overall architecture of the virtual patient system

The software system of the virtual patient was divided into three main development modules:

- Facial imaging and speech
- Reasoning (student question recognition and virtual patient answer)
- Student assessment and feedback; lecturer administration and reporting.

Figure 2.1 shows the interactions of different user groups with the virtual patient system.

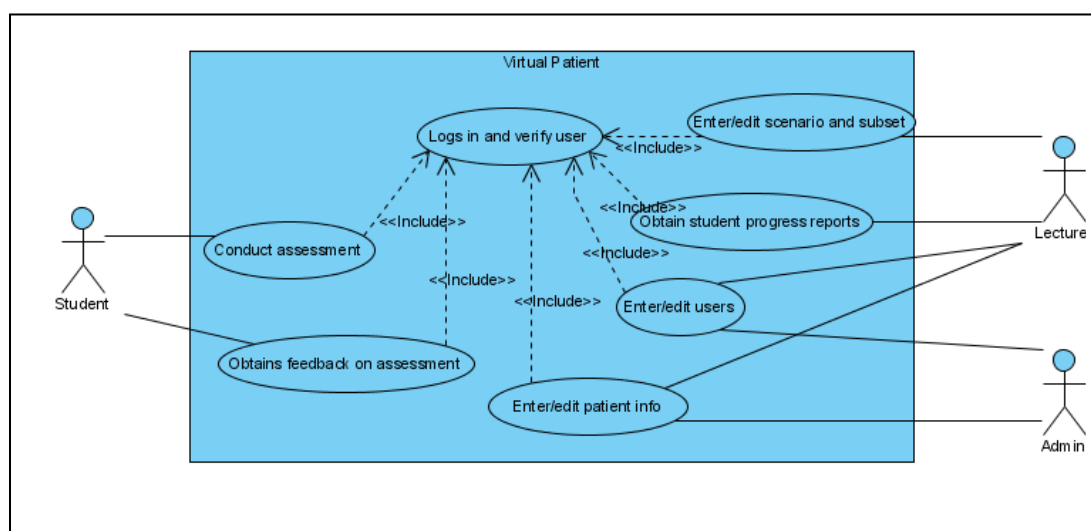


Figure 2.1: User group interactions with virtual patient system

The student being assessed interacts with the virtual patient to conduct an assessment and obtain feedback. Pharmacy lecturers interact with the virtual patient system for management of students' reports and creating or editing assessments. The system administrator interacts to add or edit virtual patient scenarios and for user (student and academic) registration and management.

The overall architecture for the virtual pharmacy patient system is outlined in Figure 2.2 below. The virtual patient system was developed as a client-server based software system. The server side consisted of the database server while the client side consisted of the virtual patient interface module which interacted with the different user groups (students, pharmacy academics and administrators).

All interactions to the server were via a database interface module. The student assessment module assigned students to a specific assessment scenario and tracked their progress. It included interfaces to the virtual patient face image and speech modules. The image and speech modules were synchronised to represent a patient's face that spoke to provide feedback to student's questions.

The reasoning module had code to recognise the question asked by the student being assessed. These questions were matched to templates held in the database on the server and appropriate answers were provided to the student via the virtual patient interface.



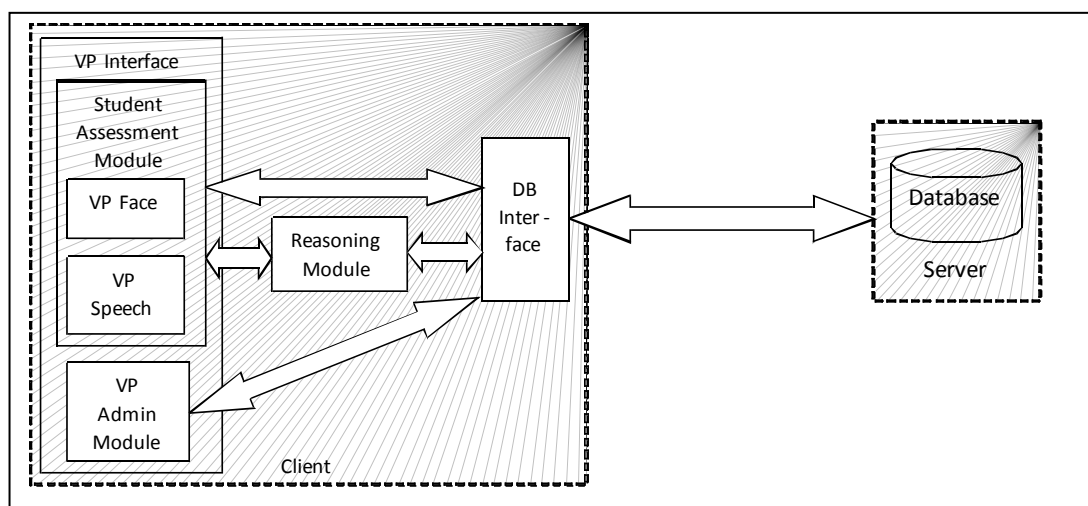


Figure 2.2: Architecture for virtual patient system

The modules of the virtual patient system are discussed in detail in the following sections.

2.4.4. Virtual patient facial imaging and speech

This module included the creation of a realistic patient image capable of varying expression and synchronisation of patient image lip movements with a commercial text-to-speech engine. The image module was largely developed and linked with a commercial speech engine at Charles Sturt University (CSU). It was integrated into the virtual patient system at The University of Newcastle where refinement of both the image background (a pharmacy) and its integration with different speech engines continued. The refinement was necessary to provide implementation capability across multiple operating system platforms at Newcastle, Monash and CSU campuses.

Efficient and low-cost techniques were used to construct a realistic three-dimensional (3D) model from two two-dimensional (2D) face images. First, a personalised 3D face model was built based on the 2D face images using Faceworx, which is a fully automatic 3D face shape and texture reconstruction framework. Second, using the software package Blender, the face model was animated by expression channels and complemented by the visual prosody channel that controls head, eye and eyelid movements. Finally, the facial animation was combined and synchronised with the emotive synthetic speech generated by incorporating an emotion transformer into a speech engine for text-to-speech synthesis – initially the speech is neutral (neither pitched to be male or female).

3D face reconstruction from 2D face image

In general, building a 3D face model customised to a particular person involves the use of an expensive 3D scanner or a calibrated camera array and tedious manual labelling work, which is not affordable for most academic applications. Computer vision researchers have therefore developed various techniques and algorithms to recover 3D face information (shape and texture) from one or more 2D face images, such as shape from shading (SFS) (Zhang, Tsai, Cryer, & Shah, 1999) and model-based bundle adjustment (MBA) (Shan, Liu, & Zhang, 2001).

The project used Faceworx <<http://looxis-faceworx.softwareandgames.com/>>, a software application that creates a 3D head from two standard 2D images showing the front and side view of a face (Figure 2.3a and 2.3b). The Faceworx software requires some skill in placing reference points and marking the contours of the face; mouth, nose, ears and eyes. The number of points in each virtual face can be changed to create a 3D real face.



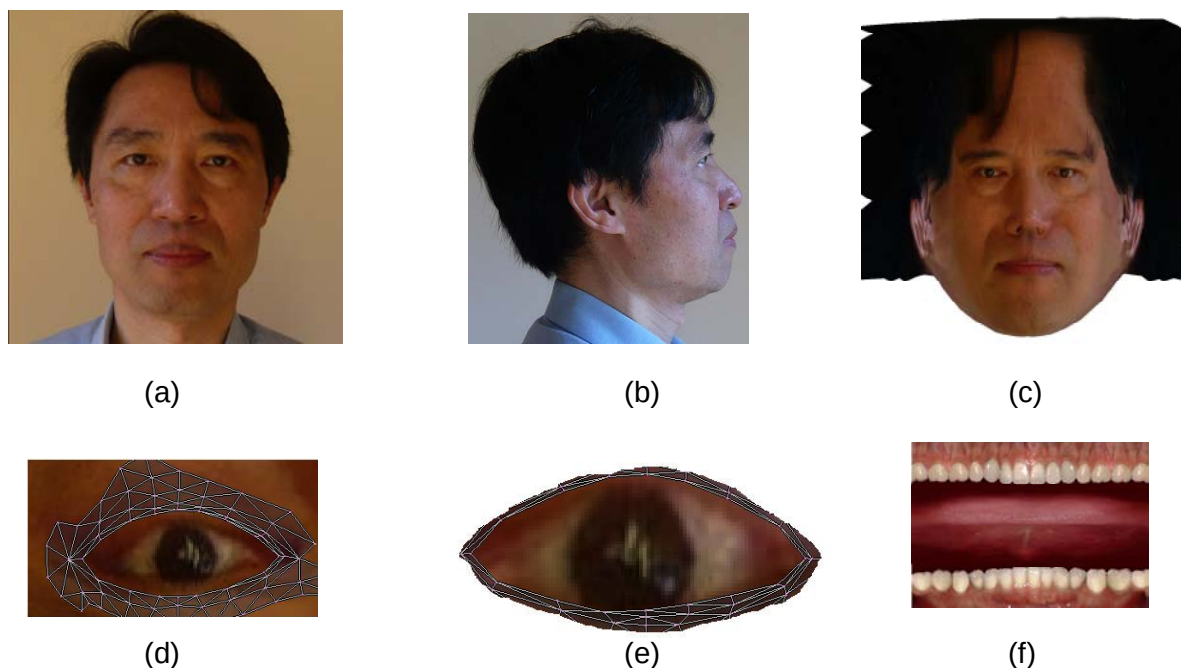


Figure 2.3: Creation of 3D face from 2D images

The final 3D portrait can be saved and exported in the well-known OBJ format (wavefront format) for use in other 3D modelling software such as Blender <<http://www.blender.org>>. OBJ is a geometry definition file format developed by Wavefront Technologies for its Advanced Visualiser animation package. The file format is open source <<http://www.sgi.com/>> and has been adopted by other 3D graphics application vendors. For the most part it is a universally accepted format.

Facial expressions

The model was imported into the software package Blender. This software uses a generic 3D model with texture mapping from a set of images. The software reconstructs a 3D head model from a set of images and generates new facial expressions. 3D models are suitable when the talking head acts with large motions and rotations, but the programming and development effort required to fit the 3D model for the set of images is extensive.

Head model

The virtual patient talking head models a human head by applying a three-dimensional mesh model, because this produces a pleasing visual appearance. A neutral face is the frontal face image without specific facial expressions. The colour information of an input neutral face provides a base image for the virtual patient system. By warping the input image, the neutral face can be 'morphed' into various expressions. A set of interesting spots are marked as control vertices around the contour of specific features on the virtual patient's face, such as the eyes, nose, mouth and chin. These control vertices are then connected into convex polygons, such as triangles. Thus, the whole image can be simplified to a set of polygons.

Face mesh fitting

The first stage in developing a talking head system is to fit a generic three-dimensional face mesh to a model's face image (Figure 2.3c). After the front and side images are added, a generic 3D mesh is applied to the face image. A boundary box is used to approximate the head size in the image and a user can manually adjust control points to



fit with feature points such as the eyes, nose and lips on the image. Most work is on the fine adjustment required for the eyelids and lips (Figure 2.3d and 2.3f).

To generate a realistic model's face, a generic face model is manually adjusted to the model's face image. To produce a personal 3D face model, both a front face image and a side image are necessary. The generic face model has all of the control vertices for facial expressions defined by a 3D movement of grid points to modify its geometry. Figure 2.3 shows a personal model, both before and after the fitting process for the front view image using the Faceworx face-fitting tool. The front and side view images are uploaded to the system and then corresponding control vertices are manually moved to a reasonable position using a mouse. The synthesised face is produced by mapping the blended texture generated by the model's frontal image and the image profile image onto the modified personal face model.

The model was constructed from a mesh of 3D points controlled by a set of conformation and expression parameters. These vertices control the relative location of facial feature points, such as the eye and lip corners. Changing these vertices can re-shape a base model to create new heads. At this stage, the virtual patient talking head has limited facial expressions and the head does not show any movement.

Mouth-shape generation

Many mouth shapes (referred to as an *alphabet*) are quite similar to each other, and all mouth shapes can be simulated by combining basic mouth shapes. In our model, 10 basic mouth shapes were adopted.

Generic teeth model

Because the input image is only a static neutral-expression face, there is no image information inside the talking head's mouth. Therefore, the teeth model is separated into two parts: the upper and lower teeth. The upper teeth model is moved according to the control vertex at the philtrum, and the lower one is moved according to the control vertex at the chin. This generic teeth model can be re-sized according to the mouth size in the neural face (Figure 2.3f). In the future, in a similar fashion to the generic teeth model, an eyeball model can be developed to change the viewing direction of the eyes.

Speech-driven face synthesis

After the 3D face mesh is adjusted, it can be used to animate facial expressions that are driven by speech. To synthesise animations of facial expressions synchronised with speech data, we must know which alphabet appears in the input speech wave data. In addition, the start and stop time of a certain alphabet should be obtained to synchronise the mouth shapes with wave data. For example, assume that the system is required to speak the sentence, "How are you?" The system invokes a speech engine and finds that from *StartTime* to *TimeA* is silence; *TimeA* to *TimeB* should be the interval taken to speak "How"; *TimeB* to *TimeC* should be the interval taken to speak "are"; and *TimeC* to *EndTime* should be the interval taken to speak "you". The system then translates these results into neutral (from time 0 to *TimeA*), How (from *TimeA* to *TimeB*), are (from *TimeB* to *TimeC*), you (from *TimeC* to *EndTime*) and appropriate key frames are fetched from the expression pool to represent these lip movements.

Speech is usually treated in a different way from the animation of facial expressions. This is because simple keyframe-based approaches to animation typically provide a poor approximation to real speech dynamics. Text-to-speech functionality allows the model to speak any text dynamically, in real time with lip-synching.

Figure 2.4 shows a flow diagram of the system synchronisation of the model's facial



expressions and speech. First, text data from a text box is fed to a text-to-speech engine. The engine compares the input text data with its own database. Then a table of mapping from alphabet to phonetic notations is used to obtain basic facial expressions. With this information, facial animations synchronised with the input text data can be generated. For example, a word “how” pronounced phonetically as /*hau*/ is converted to be /*h/ +au*/ and the corresponding mouth shape is from “h” then gradually morphed to “au”.

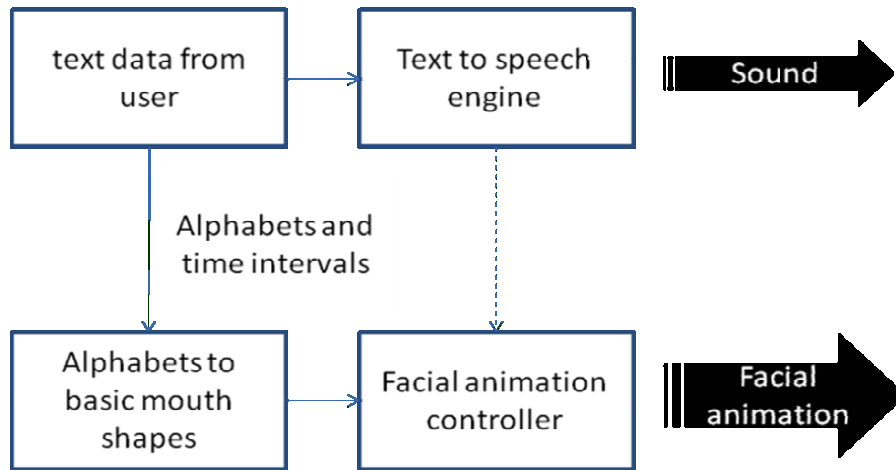


Figure 2.4: System synchronisation of the model's face and speech

Text-to-speech capabilities for a computer refer to its ability to play back text in a spoken voice. An internal driver, called a TTS engine, recognises the text and using a synthesised voice, chosen from several pre-generated voices, speaks the written text. The virtual patient system uses two kinds of text-to-speech engines. The first is the text-to-speech engine that supports the Microsoft API (MS API) from Microsoft SAPI 4.0 (Microsoft Speech Application Interface version 4.0); the other is the Java Speech API (JSAPI). For the male model, we used JSAPI and MS API for the female model.

The voice quality is very important, but is dependent on the base speech technology (SAPI 5.1) that is available on the computers on which the assessment is to be run. The Win XP standard solution was found to be not very satisfactory in terms of its speech production quality.

2.4.5. Virtual patient reasoning

For the pilot study, students were to be assessed over three days on their questioning, diagnosis and management skills for three clinical scenarios: a cough, gastro-oesophageal reflux disease (GORD), and constipation, each with three levels of severity: mild, moderate and severe (a total of nine assessments for each student). At each assessment session, the system presented a student with all three conditions at a randomly selected severity, re-assessing the same conditions at different levels of severity at an assessment session held on another day.

Some virtual patient systems, such as Web-SP (Zary et al., 2006), avoid the problems of interpreting students' free-form questions by restricting the allowed questions so that they must be chosen from a pre-formulated question bank composed by the teachers. Although this limits the scope of the range of questions to those expected by the system creators and may provide 'clues' to a student if used as an assessment, students using Web-SP found the system to be "...easy to use, engaging and to be of educational value" (Zary et al. 2006).

Adoption of a free-text style of student questioning was one of the earliest design decisions for the virtual patient. As indicated earlier, this is one of the major problem areas for current virtual patient systems. Systems that allow free-text student questions and



employ lexical analysis to obtain the semantic information such as DIANA (Lok et al., 2006) and the Arizona Virtual Patient (Farrar, 2002) typically have noticeably slow responses to questions. They perform reasonably well with a small vocabulary but when unlimited free-text questions are allowed they are prone to low accuracy as the rate of incorrectly interpreted student questions rises. This is compounded if speech recognition technology is used instead of text entry. In the development phase of each scenario for our virtual patient, a range of expected questions was developed and then this list was expanded to include as wide a variety of alternatives as possible to allow for variations in the ways that a student may correctly ask a particular question. For example, “Do you take any medicines?”, “Are you taking any medicines?”, “Do you currently take any medicines?” all of which are correct.

The conditions to be investigated were broken down into *Categories* that were expected to be investigated by a student during the assessment. Some categories consisted of standard areas that might apply across many conditions, including *Medications Taken*, *Duration* (of condition), *Other Symptoms* and *General Opening Questions*. Other categories were particular to a specific condition, such as the categories of *Normal Bowel Movements* for the constipation scenario and *Frequency of Cough* for the cough scenario. Categories were populated with questions that were expected to be asked by a student to ensure they had investigated that category.

The pilot only required that one question in a category be asked by a student to indicate coverage of that category, but the system is capable of finer reporting detail and can separate questions into specific *sub-categories*. For example, the category *Duration* (of a condition) was sub-divided into *Start* (of the condition), *Duration* (interval of the condition) and *Existence* (of the condition). This enables finer reporting in the future and also caters for the analysis logic necessary to determine appropriate sequencing and style of the questions asked by students. In some cases, the sub-categories were chosen based on grouping the open-ended and closed questions contained in the category, for example the *Frequency of Cough* in the cough condition was subdivided into *Frequency of Cough-Closed* and *Frequency of Cough-Open*. In other cases, the sub-categories were associated with specific groups of questions, for example *Other Symptoms-Runny Nose*, *Other Symptoms-Aches*, *Other Symptoms-Fever*, and so on, for the cough condition.

The pilot study assessed the students' ability to take an oral history. The main design problem was correctly interpreting a student's question in order to categorise it against a list of expected questions that needed to be asked to investigate the clinical condition. Once the student's question had been recognised and associated with one of the expected questions, a suitable answer could be easily supplied to the student by the virtual patient. If the virtual patient did not understand the student's question (it could not be matched against any of the expected questions) then the virtual patient responded that it did not understand the question and requested that the student re-phrase and then re-enter it. The virtual patient used three different (randomly selected) requests to do this so that the student being assessed would not be frustrated by the system response.

The student question was tokenised into individual words after it has been input into the virtual patient, and then punctuation and irrelevant words were removed. The student question was stored in both tokenised form and its complete original form by the virtual patient for reporting the chronological sequence of student question – virtual patient answer, but the virtual patient system logic operated on the tokenised form of the student question.

Matching of the tokenised student question was done initially against a list of tokenised phrases that represent variations in phrasing of the expected questions (each variation will only map to one expected question). The expected questions were termed *target*



questions and the variation phrases were termed *alias questions*. For a specific domain category, there could be many aliases associated with a particular target question; however, each target question was matched against only one category/sub-category combination for a specific condition and severity. Each target question for a particular condition and severity was also matched to one virtual patient response (patient answer).

As the pilot was not intended to produce new reasoning algorithms, initially the reasoning was only based on data matching of the tokenised question against a target question (also tokenised) in the virtual patient. This was trialled with experienced pharmacists at a seminar at Hobart in 2009 and the system was found to have a 50 per cent question-recognition rate. Based on these results, a secondary filter scheme, using keyword matching with wildcards to target questions, was implemented as a fallback for the initial data matching to tokenised target questions. If a student question was not recognised initially by the data-matching process (tokenised student question to tokenised target question), then an attempt to match it with a keyword “filter” (consisting of keywords and wildcard characters) was made. If a match with a filter keyword was found, the virtual patient responded to the student “If you meant to ask ...” – the virtual patient then provided the target question that the keyword filter was matched to – “then the answer is...” – and the virtual patient then provided the answer corresponding to the target question for the appropriate condition and severity being assessed. If no match was found to the initial tokenised target question data-matching, or to the subsequent keyword filter, the virtual patient responded that it did not understand the question and asked the student to re-phrase and re-enter as before. This improved the virtual patient question recognition to be comparable with the DIANA system recognition rate and allowed for simple keyword filters to encompass many aliases. Addition of keyword filters was not incorporated in the teacher interface due to the complexity of finding suitable keywords with filters and assigning them to an appropriate target question. The keyword filters were entered directly into the SQL Server database.

The virtual patient captures student questions that it has not recognised in an assessment. Following assessment sessions the system provides a teacher with the ability to view and analyse these unrecognised questions and, if they are questions that the virtual patient should recognise, add them to the virtual patient lexicon database using the virtual patient–teacher interface. If there are multiple valid student questions that the virtual patient has not recognised, a request may be made to the knowledge engineer to incorporate an appropriate keyword filter into the virtual patient.

The virtual patient student interface in the tutorial mode has a learning module (Figure 2.5) that can be incorporated into it when the system is being used in a training mode by a student (rather than in assessment mode). When incorporated, the system adopts a hill-climbing recognition approach to student question interpretation. The design assumption is that the student is asking a question related to X. If the student’s phrasing of the question is not recognised by the system then the student will re-phrase the question but will still be asking about X, albeit in a slightly different way. If a correctly recognised question is entered the student will be presented with all their unrecognised questions (since their last correctly recognised question) and asked to indicate if any of the unrecognised questions correspond to the currently entered and recognised question. In this manner the virtual patient acts in a training mode and “learns” alternative phrasing for its list of expected questions, thus building its lexicon for future matches between student questions and expected questions. In the example shown in Figure 2.5, the unrecognised questions “What seems to be the matter?” and “What seems to be your problem?” can be added to the lexicon as aliases of the target question “What is wrong?”.

Note that in Figure 2.5, text boxes for the virtual patient answer and expression are shown but these will be hidden during a real assessment.



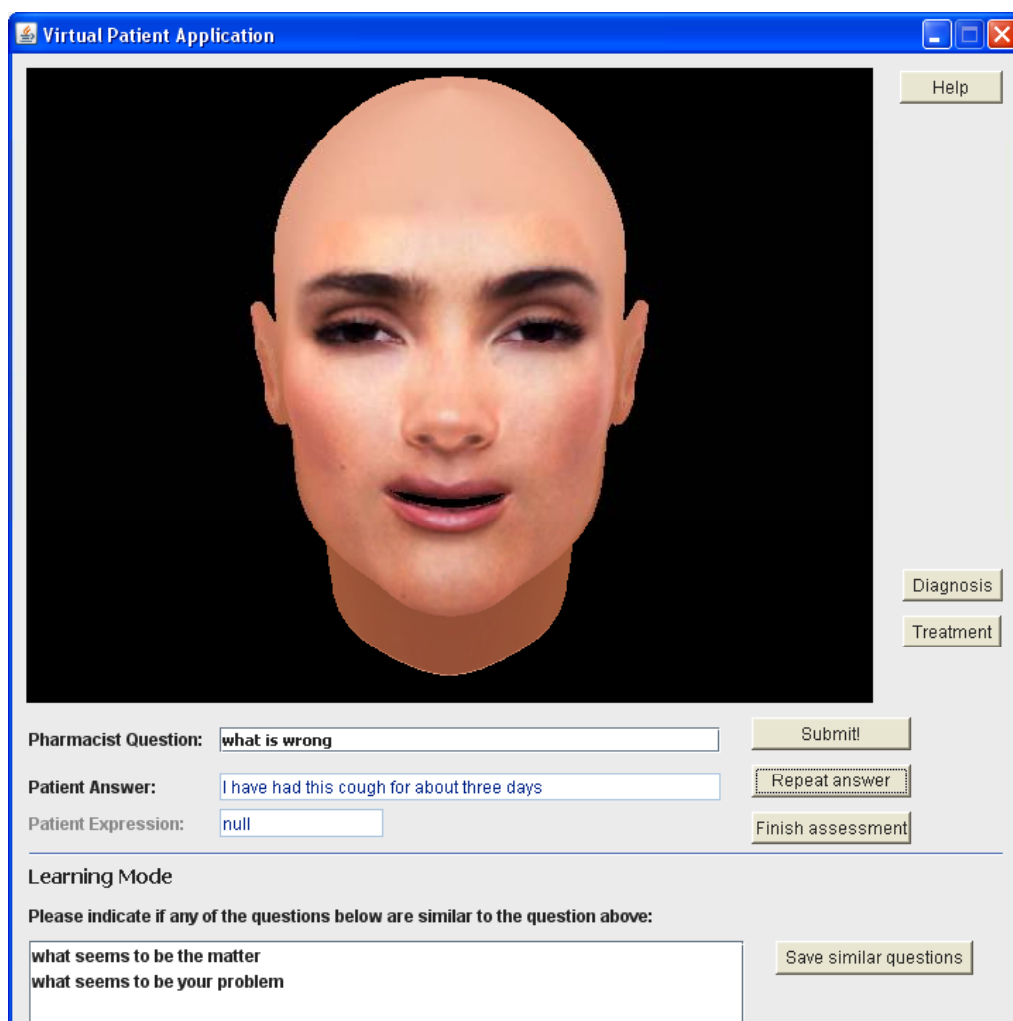


Figure 2.5: Virtual patient student question with learning mode

2.4.6. Assessment and knowledge base preparation

A knowledge engineer and pharmacy academics worked together to populate the database required for the virtual patient reasoning. Pharmacists provided input for each condition and the severity of the categories and sub-categories that would be desirable to assess. Specific assessment conditions, such as whether a student was expected to use only open-ended questions for a specific category, or whether questioning of the category should start with an open-ended question, could be set. In addition, pharmacists supplied the rationale for the style of questioning and the types of question that were expected for that specific category. An example of the 'General Opening Questions' category for a cough is illustrated in Figure 2.6.

For a specific condition and severity, pharmacists could delete sub-categories or could add them, either using existing sub-categories from other condition/severity combinations, or by creating a new sub-category.



Admin - Condition Category & Rationale Details

Condition Category & Rationale Details Help

Specify the question requirement and Rationale for each condition category.

Condition: Cough

Category: General opening questions

☒ Only Open Questions
☐ Only Closed Questions
☐ Should Start with Closed Question
☐ Should Start with Open Question
☐ No Restriction

Rationale

A good open ended question to start will mean you usually need to ask less questions

Submit Cancel & Return

Figure 2.6: Category question type specification

Admin: Questions and Answers Help

Condition Category Questions & Answers

Specify the question requirement and Rationale for each condition category.

Clinical Condition: Cough Variation: mild

Question Category: Other symptoms

Existing Sub-Categories:

- Other Symptoms - Closed
- Other Symptoms - Open
- Other Symptoms - Fever - Closed
- Other Symptoms - Aches - Closed
- Other Symptoms - Nasal - Closed

Possible Sub-Categories:

- Other symptoms - straining

Create New SubCategory Edit Selected SubCategory

New Question

Question: Do you have a fever

Answer: No

Question Type: closed

Patient Expression: Smile

Save Question Cancel Question Edit

Add Alternative Question Phrasing Specify Secondary Logic

Cancel & Return

Figure 2.7: Specification of sub-category and target question



As seen in Figure 2.7, pharmacists could also indicate the ideal or 'target' student question that would be expected to be asked by a student and the target question type, either closed or open ended. Pharmacists could also select the 'Add Alternative Question Phrasing' option in Figure 2.7 to enter 'alias' questions – questions with a similar meaning to the ideal target question but with different phrasing – for a specific condition and severity. The aliases are added by either typing/pasting in a new question or by adding an existing alias from another condition/severity combination. The specification of aliases is shown in Figure 2.8.

Figure 2.8: Specification of aliases to a target question

The ability to create new sub-categories with their indicative target question/answer for a specific condition/severity pair, and the ability to specify aliases by re-using existing aliases from the knowledge base or by creating new aliases, allows pharmacists to use the existing knowledge base and to add to it, thus building a lexicon for the domain.

In addition to the ability to add to the lexicon and manage the domain knowledge base, the virtual patient system provides an interface for pharmacists to specify simple logic rules for the assessment. By choosing the 'Specify Secondary Logic' option in Figure 2.7, for a specific condition/severity pair and a specific sub-category, pharmacists can specify a conditional relationship indicating whether particular target questions are not appropriate to be asked if a specific question has been asked previously. Figure 2.9 shows the logic rule interface for simple following questions for an assessment of a patient with a mild cough. If a student asks "Do you have any other symptoms?" and has already asked "What other symptoms do you have?", then the system provides a response but records this as an inappropriate question sequence and will provide this feedback to the student at the end of the assessment.



Figure 2.9: Interface to specify simple logic rules for intra-category question sequence

Initially, the assessment criteria specified that only one question needed to be asked from any particular category and that there was no required order in which the categories needed to be addressed, that is, no required sequence to the questioning order of the categories. Only the logic necessary to specify questions that were not appropriate following a specific question from the same category being asked was specified in the reasoning module.

The inter-category question logic was addressed in the second part of the assessment criteria; however, it was modified in the later stages of the prototype. Initially, the specifications dictated that there was no need to indicate if the questioning by the student in any category was required or not required to follow questioning in any other category. However, it became apparent in beta testing that follow-up questions between categories had to be flagged and indicated. The initial specification was followed to the extent that no logic rules were implemented to indicate that a student addressing one category (questioning in one category) after addressing a different category was incorrect. The modification was to the requirement for a follow-up question from a category in response to the answer of a question from another category. The rules depend on the answer from the virtual patient to the initial student question. For example, if a specific question such as “Are you on medication?” is asked by the student and the virtual patient’s answer is “Yes”, then follow-up questions regarding the nature of the medication, or of what symptoms the medication is for, are generally required from the student. The converse is also true: if a symptom is described by the virtual patient then the student would be expected to provide follow-up questions on whether medication is being taken for it. The system has an interface to enable pharmacists to specify simple logic rules for questions that may be required to be asked in a specific category following a specific question being asked by a student from another category. The reasoning employed for inter-category questions and the specification of these types of rules is shown in Figure 2.10.



Inter Category Required Follow-up Questions

Condition:

Category: Sub-Category: Severity:

Target Question: Answer: Answer Type:

Required Follow-Up Question for Selected Condition Question

Following Category:

Target Question	SubCategory	Answer	Type	Re...
What have you tried	Self Treatment Open	Nothing	open	☐
Have you taken anything for it	Self Treatment Closed	No	closed	☐

Figure 2.10: Specification of inter-category required follow-up questions

Repeated questions from the student, such as when a student may ask two or more alias questions that map to the same target question, are also logged by the virtual patient system. As well as being logged and indicated in feedback at the end of the assessment, these are indicated immediately to the student by the patient speaking the correct response to the target question but prefaced by “You have already asked that but the answer is ...”

Pharmacists also supplied the ideal diagnosis and treatment for specific patient conditions and condition severities (Figure 2.11).

Admin - Diagnosis and Treatment Details

Adding the diagnosis and treatment for specific condition and severity.

Condition: Severity:

Diagnosis:

Treatment:

Figure 2.11: Ideal diagnosis and treatment specification for a condition/severity pair



2.4.7. Student assessment/feedback, lecturer administration and reporting

The virtual patient system captures and records student questions to the virtual patient and the answers provided by the virtual patient to the student. This allows individual students to view their assessment, or for assessments to be later interrogated by a teacher to examine the chronology of a student's reasoning in fine detail (if required).

The system provides formative feedback to students. A complete feedback summary can be presented to a student at the end of each of their assessments (a specific condition-severity pair). For a summative assessment, a full summary would not necessarily be provided at the end of each condition-severity pair assessment, but might be provided at the end of the complete assessment of all condition-severity pairs.

Student Assessment

When a student logs in to the virtual patient system for an assessment, the assessment module looks at the student's past history of assessments and decides on the appropriate condition-severity level pair to use for that individual student, and also indicates to the face module which gender and face to produce for the assessment. The student asks the virtual patient free-form questions regarding the patient's condition and the virtual patient produces an oral response to the student, accompanied by an appropriate visual expression. In this process, the assessment module accepts the student's free-text entry and passes it to the reasoning module, which analyses the student question and supplies appropriate responses and associated expressions to the face module to vocalise and display.

Following logging in to an assessment session, a student will be randomly allocated a specific condition/severity pair and either a male or female patient (Figure 2.12 below)

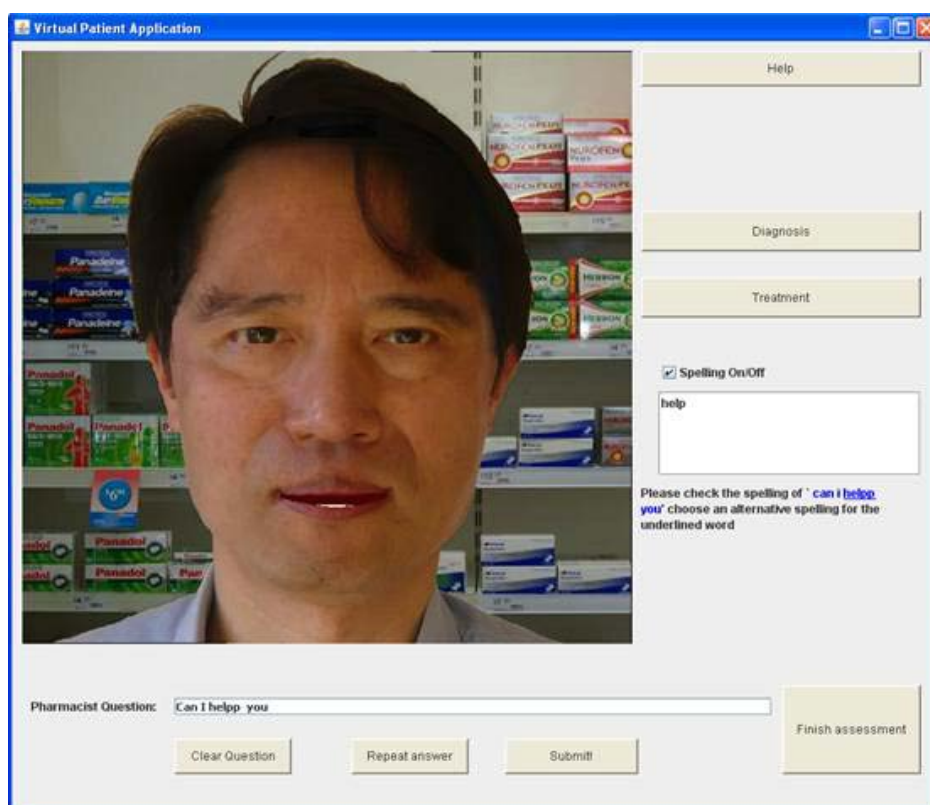


Figure 2.12 (a): Male patient



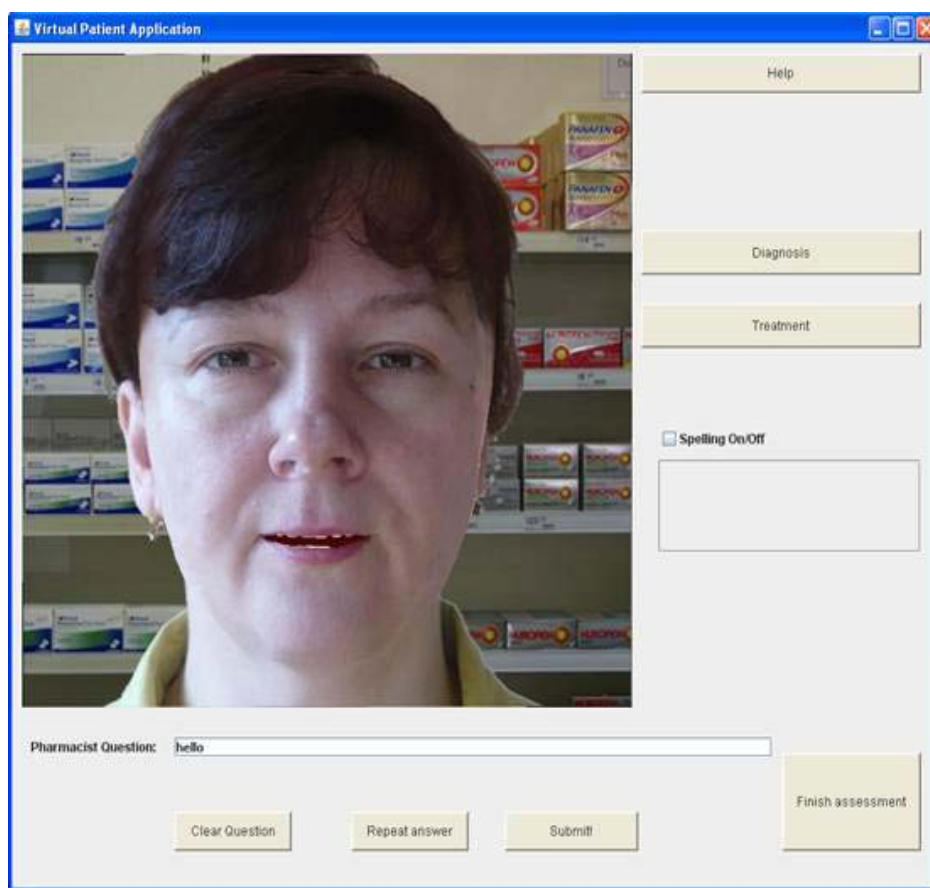


Figure 2.12 (b): Female patient

Student Feedback

During a student's assessment session, feedback is provided in response to specific student questions, and as indications that the student had asked the same question previously or that the virtual patient has not understood their question. A list of inappropriate words is stored in the virtual patient and if the student's question includes swearing or if the student has used an inappropriate word from that list, the virtual patient will issue a response indicating that they are offended by the student's language. Unsolicited responses from the virtual patient issued at appropriately timed intervals after the assessment has started also provide feedback clues to the student that they need to finish the interview. These include a random selection of statements such as "Will this take long, I need to catch a bus in 5 minutes". In later systems, emotions could be associated with these types of feedback in the virtual patient's face, where the virtual patient might frown or appear visually frustrated.

During the assessment, the system records the student's diagnosis of the condition and also their recommendations for treatment, using separate forms from the assessment questioning interface form (Figure 2.13). The student can select these forms using buttons (in Figure 2.12) to develop progressively, and also correct, their suggested patient diagnosis and patient treatment, with content able to be added and modified at any time throughout the assessment. At the end of the assessment, the student is provided with feedback showing their diagnosis and their recommended treatment, as well as a comparison to the correct diagnosis and recommended treatment (supplied by their teacher in accordance with the current evidence-based recommendations).



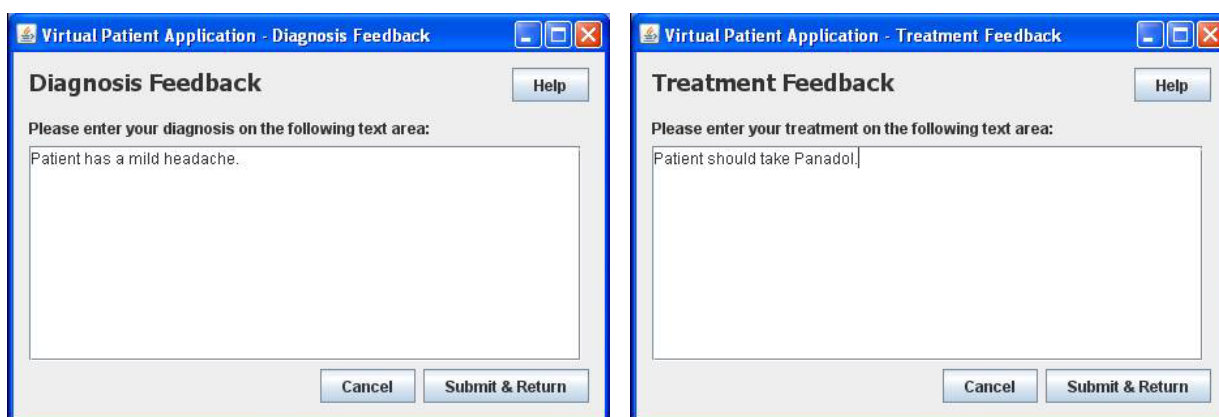


Figure 2.13: Student's diagnosis and treatment entry screens

At the end of each assessment the system provides feedback to the student on their coverage of the scope of questions normally expected to be covered by a student when taking an oral history for a particular condition. At the end of their assessment for a particular condition-severity pair, they are shown a small (random) selection of question categories for the condition being investigated that they have not asked the virtual patient about, together with examples of a question that might fall into that category (Figure 2.14).

Assessment Feedback Report

Student name: Test Student user
Assessment Date: 2010-07-07 14:33:43.893

You have covered the following question categories:

- Duration
- General opening questions
- Medication Preference
- Salutation

Repeated Qs
Inter Category Qs
Non Appropriate Qs

However, You could have asked questions on the following categories:

Domain	Example Questions
Alarm symptoms	Is there any chest pain
Allergies	Do you have any allergies
Description of presenting symptoms	Can you describe what it is like when you go to th...

Unreported Question Category Open/Closed Questions Assessment Hist...

Your final diagnosis:
The patient has been constipated for more than a week and wants a Laxative

Actual diagnosis:
The patient appears to have constipation secondary to poor diet and lifestyle.

Your final treatment:

Actual treatment:
Although it has been going on for several weeks, there do not appear to be any alarm symptoms such as blood in the stool or suspected depression. They are also not taking any medications that could be cau...

Save/Print Report Print Qs Report Exit

Figure 2.14: Summary form displayed for student feedback



At the end of each assessment, students can also see and print a report showing a chronological history of all their questions and the system answers for the assessment scenario (Figure 2.15).

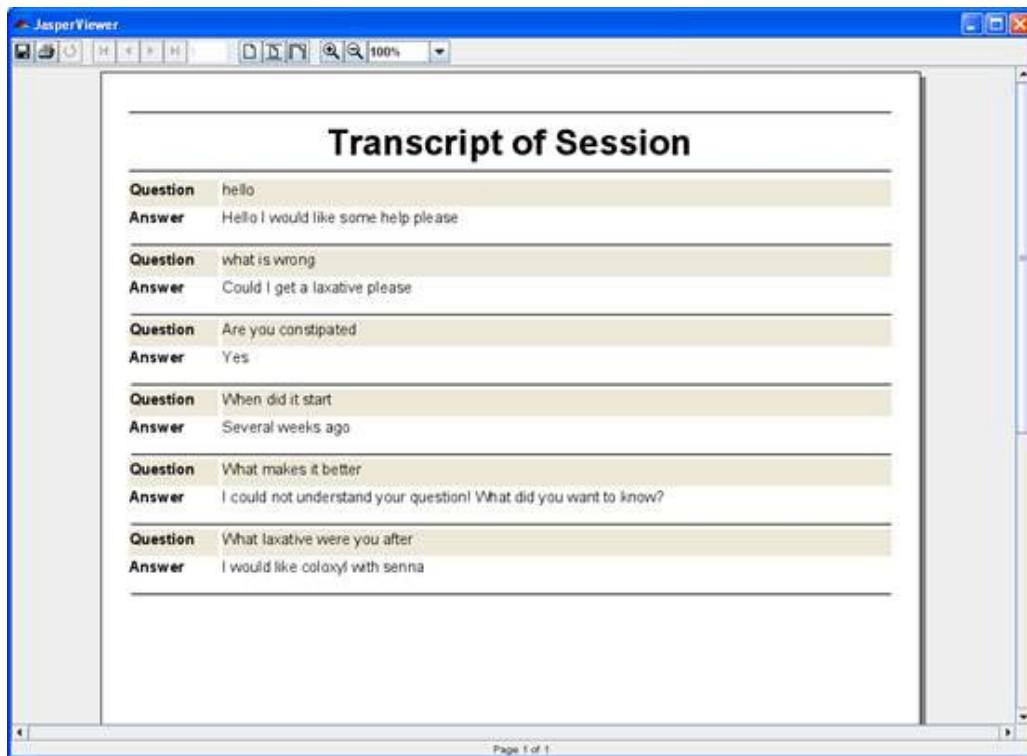


Figure 2.15: Chronological student question – system answer report

Students are provided with a complete feedback indicating all categories that they had not covered in their questioning (without example questions) together with the rationale for asking each category (Figure 2.16).

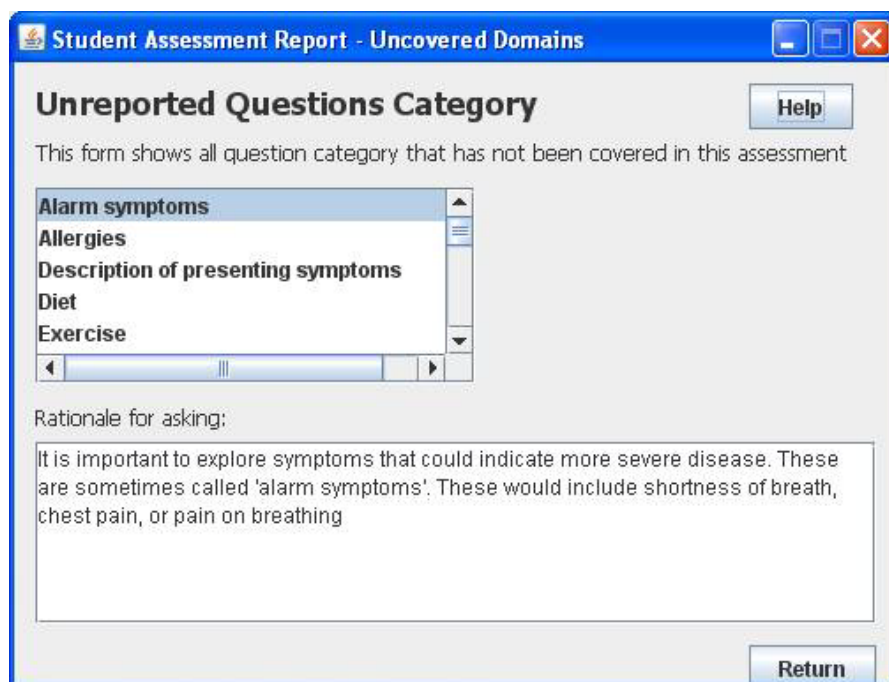


Figure 2.16: Scenario categories not covered by student questioning



The virtual patient system described here is novel compared with other virtual patient systems in that it provides feedback on the *style* of student questioning. It provides feedback to the student on whether they had asked repeated questions and whether they had asked *appropriate* questions. The appropriateness of questioning involves an analysis of the type of questions they asked. Feedback is given to the student on whether they:

- repeated questions for which the virtual patient had already supplied answers
- asked too many closed questions rather than more appropriate open-ended questions in the overall assessment
- used an appropriate general sequencing of their questions for specific categories, such as when a category requires that an open-ended question should be asked before a closed question. For example, if a student initially asks a closed question such as “Have you had it long?” instead of a more appropriate open-ended question such as “How long have you had it?” or “When did it start?”
- asked inappropriate or illogical questions within a category. For example if they asked a female representation of the virtual patient “Are you breastfeeding?” and then asked “Are you pregnant?”
- asked appropriate follow-up questions in response to particular answers from the virtual patient. For example, if the virtual patient had indicated they were taking a specific medication then an appropriate follow-up category would be to determine what condition they were taking it for (and vice-versa).

Students can print out the feedback provided by the virtual patient system at the end of each assessment to use in later remediation.

Teacher Assessment Management

Ease of the management and reporting of assessments, and scalability of the clinical domains and the domain condition scenarios exhibited in the early Monash University virtual patient (Marriott, 2007) and the Web-SP (Zary et al., 2006) virtual patient systems, have been adopted in the general design philosophy of the virtual pharmacy patient system.

Although the domain scenarios (conditions) used for the pilot assessment implementation of the current virtual patient system were limited to three conditions and to conditions that need to be diagnosed by pharmacists, the virtual patient system itself is scalable to conditions and domains other than those related to pharmacy. The domain content is initially determined by the domain teachers in their roles as administrators of the knowledge content of the system domain; however, the knowledge base of the virtual patient system can be expanded by both domain teachers and by students when it is used for formative training. This gives the virtual patient system the potential to be used in most health disciplines where structured questioning is important.

Teachers log into the virtual patient system as administrators and are responsible for the content of the clinical domains to be assessed. As shown previously, teachers can easily modify existing domains, categories and sub-categories; and they can add new ones without further programming (Figure 2.17). They can specify and easily modify, the types of expected questions associated with particular conditions/categories/sub-categories. They can specify and can modify the answer, the answer type (closed or open-ended), and the face expression provided by the virtual patient for different severity levels of particular conditions/categories/sub-categories.



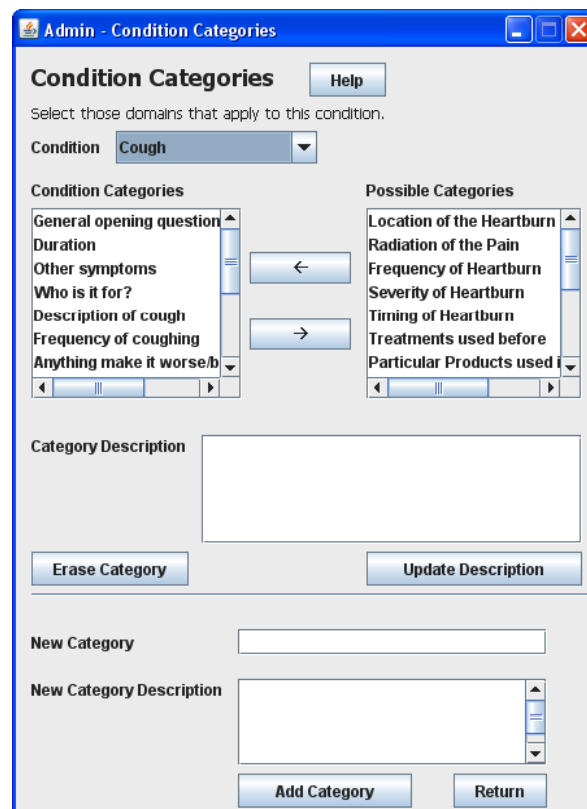


Figure 2.17: Virtual patient teacher category management

As indicated earlier, a specific domain can have many aliases associated with a particular target question, that is, with a specific condition/category/sub-category combination. This helps to define sub-categories as, if a new question is formulated for a specific condition and category that cannot be associated with an existing sub-category, a new sub-category is formed and the question is associated to this sub-category as its target question (expected question).

Teachers can easily increase the capability of the reasoning logic by entering alias questions to match target questions for a specific condition/category/sub-category (Figure 2.18). This ability to expand the system lexicon enables the system to 'learn' and become more efficient in future assessments as a result of its increased student question recognition capability. Once alias questions are stored in the virtual patient database for a particular condition/category/sub-category, they can be easily transferred and used for any other condition/category/sub-category. This adheres to the scalability goal of the virtual patient as it enables a quick population of the recognition knowledge for new conditions.



Figure 2.18: Virtual patient teacher management of aliases for target questions

Teachers can also specify the domain conditions that the reasoning logic will use for assessment. They can specify both intra-category and inter-category conditions and restrictions through the teacher–management interface.

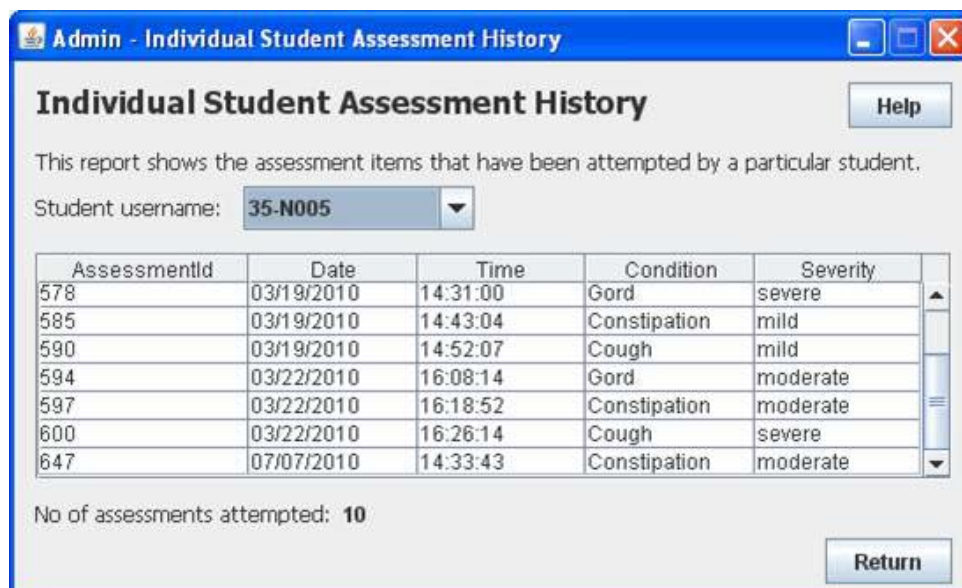
Intra-category conditions place assessment restrictions on the target questions of the category, such as whether a category should be questioned using only its open-ended questions, or only by its closed questions, or whether it should be questioned starting with a closed- (or open-) ended question. Given that the student has asked a particular target question from a specific category, teachers can also refine the assessment logic, using a simple interface, to indicate what other target questions within the category are inappropriate to follow. An example (discussed earlier) is asking whether a (female) patient is pregnant given that the student has already asked if the patient was breastfeeding.

Inter-category conditions place assessment restrictions on target questions that appear in different categories. These usually have a relationship that depends on the answer supplied to the student by the virtual patient (the answer is dependent on the condition/category/sub-category/severity). For a specific condition and severity, given that the student has already asked a particular target question (that is, in a given category/sub-category) and has received an answer to that question, an easy interface allows teachers to specify what follow-up questions *should* be asked by a student from other categories and sub-categories in response to the answer provided to the student by the virtual patient. The example given earlier related to a question/answer relationship between the medications taken and the patient conditions. If the patient has answered “I have high blood pressure” in response to a student question about what medical conditions they have, the student is expected to then ask about the medications they take for it (and vice-versa). Another example is if a patient has specified that they do not have a medical condition, a teacher might still require a student to check whether they are taking medications in general or specific medications.



Teacher feedback

The virtual patient provides reports to teachers relating to individual student performance over a specific assessment or over all assessments, and of aggregated class performance over specific conditions, categories and sub-categories. The aggregated report indicates how many students attempted each category for each condition/category/sub-category. This allows the teacher to obtain an overall view of the class performance and indicates areas in which they require remediation. An example of the aggregated report is shown in Figure 2.19.



Admin - Individual Student Assessment History

Individual Student Assessment History

This report shows the assessment items that have been attempted by a particular student.

Student username: **35-N005**

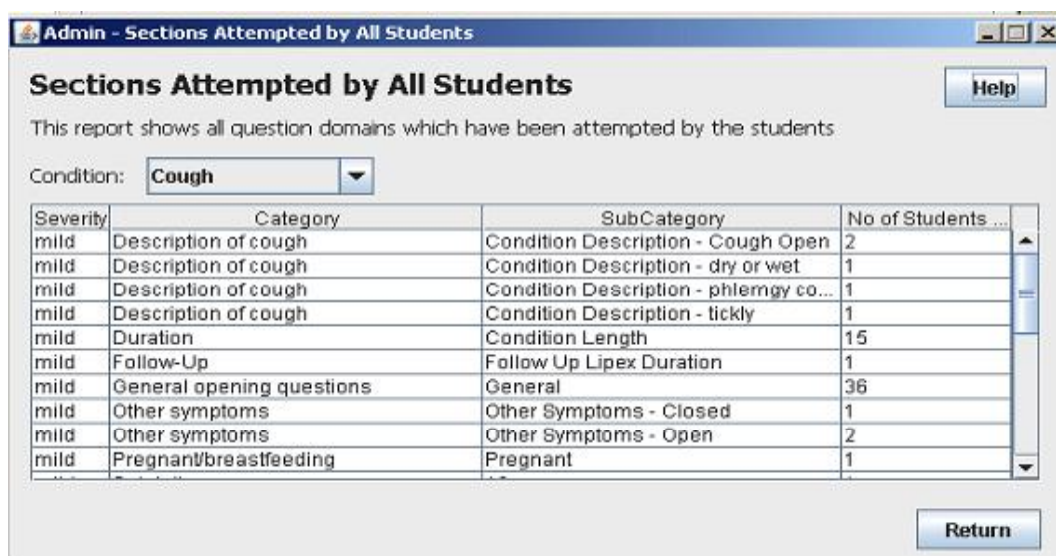
AssessmentId	Date	Time	Condition	Severity
578	03/19/2010	14:31:00	Gord	severe
585	03/19/2010	14:43:04	Constipation	mild
590	03/19/2010	14:52:07	Cough	mild
594	03/22/2010	16:08:14	Gord	moderate
597	03/22/2010	16:18:52	Constipation	moderate
600	03/22/2010	16:26:14	Cough	severe
647	07/07/2010	14:33:43	Constipation	moderate

No of assessments attempted: **10**

Return

Figure 2.19: Aggregated report for specified condition

Teachers can also 'drill down' to look at an individual student's assessment history, providing a report of the performance of an individual student over all of their assessments (Figure 2.20), as well as focusing on a specific assessment for an individual student with a report on the transcript of student question/virtual patient response for a particular assessment (Figure 2.21).



Admin - Sections Attempted by All Students

Sections Attempted by All Students

This report shows all question domains which have been attempted by the students

Condition: **Cough**

Severity	Category	SubCategory	No of Students ...
mild	Description of cough	Condition Description - Cough Open	2
mild	Description of cough	Condition Description - dry or wet	1
mild	Description of cough	Condition Description - phlemgy co...	1
mild	Description of cough	Condition Description - tickly	1
mild	Duration	Condition Length	15
mild	Follow-Up	Follow Up Lipex Duration	1
mild	General opening questions	General	36
mild	Other symptoms	Other Symptoms - Closed	1
mild	Other symptoms	Other Symptoms - Open	2
mild	Pregnant/breastfeeding	Pregnant	1

Return

Figure 2.20: Individual student assessment history (all assessments)



Admin - Individual Student Questions

Individual Student Questions Help

This report shows all questions being asked by a student in each assessment.

Student username: **35-N005**

Assessment ID: **590-mild Cough** Show Questions

Question	Answer
what are your symptoms?	It is a dry cough
do you have other symptoms?	Yes
what other symptoms?	I have a bit of a runny nose and I am just feeli...
are you on any medication?	No
do you have any allergy?	No I don't have any allergies
have you had it before?	Yes
when do you have it?	NA - NOT APPLICABLE
have you taken anything to make you feel b...	Good

Return

Figure 2.21: Individual student assessment report for specified condition

The virtual patient provides a printable report to teachers of all the student questions that were not recognised by the virtual patient (unmatched to its lexicon database) during all assessments (Figure 2.22). This allows a teacher to review the questions and then, if required, to add them easily to the lexicon of aliases and so expand the knowledge base of the virtual patient. It also provides the teacher with a checking capacity, in that an unrecognised student question may identify a potential new target question.

JasperViewer

Unmatched Student Questions

assessmentid	Condition	Severity	questionText
468	Constipation	mild	are you in much pain?
468	Constipation	mild	are you in pain
468	Constipation	mild	are you in pain?
468	Constipation	mild	good
468	Constipation	mild	have you tried any other treatments?
468	Constipation	mild	is it painful
468	Constipation	mild	is this for your self?
468	Constipation	mild	what is the consistency of your stools?
468	Constipation	mild	when did you become constipated?
469	Constipation	severe	any abdominal pain
469	Constipation	severe	any pain
469	Constipation	severe	do you have any abdominal pain
469	Constipation	severe	do you have any stomach pain
469	Constipation	severe	have you ha this problem before
469	Constipation	severe	how often are you passing stool
470	Gord	severe	are you in pain?
470	Gord	severe	did that make it better?
470	Gord	severe	did the antacid help?
470	Gord	severe	did the remeze make it better?
470	Gord	severe	do you take it with food?

Page 1 of 30

Figure 2.22: Report of unmatched student questions



2.4.8. Hardware and software requirements

The following table summarises the hardware and software requirements for installation at the different campuses over which the virtual patient system was implemented.

Table 3: Hardware and software requirements

University	Software		Hardware	
	OS	SQL	RAM	CPU
Newcastle	Virtual Windows XP with Service Pack 3 ¹	MS SQL Server 2005 Standard Edition ²	2GB	Apple MAC
	The IT professional deployed the application to the whole computers and the database administrator managed the database server and created the connection string to the database.			
Tasmania	Windows XP with Service Pack 3 ¹	MS SQL Server 2005 Standard Edition ²	2GB	Intel® core™2 Duo
	The IT professional at Tasmania Uni initially installed the application. The IT professionals and the database administrator from Newcastle University updated the application and managed the database server.			
Monash	Windows XP with Service Pack 3 ¹	MS SQL Server 2005 Express ^{2,3}	2GB	Computer 1 Intel® core™2 Duo Computers 2~8 Intel® Pentium 4
	The IT professional from Newcastle University installed the application and managed the database server. The project IT team communicated directly with the company from which the computers were hired to specify the system requirements.			
CSU	Windows XP with Service Pack 3 ¹	MS SQL Server 2005 Express ^{2,3}	2GB	Intel® Pentium 4
	The IT professional at CSU communicated with the IT professional at Newcastle University through emails and phone to install the application and manage the database server.			

¹ This software is required for all computers in which the virtual patient application will be deployed.

² This software is only required for the server in which the database will be installed.

³ This is free software. When this version is used, specific configurations are needed (See Installation Guide for Developers).

Note: The application requires a screen resolution of 1024×768 pixels or above.

The minimum hardware requirements for the application are: RAM: 2GB or above, CPU: Intel® core™2 Duo CPU 2.09 GHz or above. If the hardware specifications are less than these, clients will experience slow speeds when using the virtual patient system

There were three versions of documentation for installation at the various campuses: the installation instruction for administrators, the installation instruction for clients, and the user manual. Each of the three zip files described below contain a Microsoft Word document that details the installation instructions. This file is called 'InstallationManualMira_Distribution.doc'.

The software is available at

<<http://resweb.newcastle.edu.au/VirtualPatient/private/uploads/>>

Username and passwords can be requested from david.newby@newcastle.edu.au

The link enables access to three zip files:



- CarrickAssessment.zip - student assessment application (does not include software such as NetBeans)
- CarrickDevelopment.zip - student assessment application plus all required software (such as NetBeans) and source code
- CarrickTutorial.zip - tutorial system for students (does not include software such as NetBeans).

2.5. How the project advances our existing knowledge

The development of virtual patients in rudimentary forms for the education of health professionals was proposed early in the development of information technology, but the lack of their widespread implementation may reflect the difficulty of accurately simulating human responses in a clinical situation. It has only been in recent years that computer technology capable of simulating human expressions has been sufficiently affordable to consider its application to the education of health professionals.

In a recent review of virtual patients used in health professional education, Cook and Triola contend that virtual patients are ideally suited to assist in the development of clinical reasoning skills. They also suggest that, to be effective, the design of virtual patients should include the provision of feedback, repetitive practice and clinical variation (Cook & Triola, 2009). These principles are well established in both educational theory and evidence (Ericsson, 2004).

This project developed and trialled a virtual patient for use by pharmacy students using these three principles applied to clinical reasoning and communication for primary community care. The program used student-led questioning to determine the information provided, and then provided written feedback (electronic or hard copy) on questions that should have been asked, including the reasons for asking them. This proved to be the aspect of the program cited as the most valued by students in the focus groups, and in the post-test over 80 per cent of respondents agreed that the feedback was helpful in enhancing their diagnostic reasoning skills. (See Evaluation section for further details.)

Some students, particularly those who had less outgoing personalities, also valued the opportunity to practise clinical reasoning in an unpressured situation, as opposed to practising with other students and/or staff watching and critiquing. By practising with the virtual patient, these students felt they could gain more confidence, and so would feel less intimidated by role-plays in the course or dealing with people in pharmacies. The opportunity to gain more practice in clinical reasoning was also appreciated by students who had less community pharmacy experience than their peers, and so the virtual patient was seen as having the potential to 'even out' some of the disparity in experience that inevitably occurs between students.

In terms of clinical variation, the virtual patient had three conditions, and each scenario had three levels of severity, giving nine clinical scenarios. However, for each condition the same 'person' was presented for each scenario of the three levels of severity. Focus group feedback suggested that, while students found the differing levels of severity interesting and helpful, some students found it difficult to relate to the same 'person' presenting a different scenario, particularly when it presented very similarly to a previous one. Some students suggested that it would be easier to relate to a different 'person' presenting a different level of severity.

Students at all three universities also suggested graded programs, so that programs with higher levels of guidance could be made available to students earlier in their course, for example through the use of drop-down menus to choose from a list of available questions.



Overall, this project has shown that, even despite technical problems, students are generally positive about using a virtual patient and gain most from written feedback on their performance with explanations of how they could improve. The opportunity for repetitive practice is particularly appreciated by subsets of students who feel at a disadvantage in clinical reasoning and/or community pharmacy practice. This may be an avenue to pursue in future. While variation of clinical scenarios is important, it may need to be matched by variation in the persona of the virtual patient in order for students to be able to relate to the virtual patient as a separate scenario. Finally, graded versions of the virtual patient may also be a useful avenue to explore, with more directed versions for earlier stages of pharmacy education.

2.6. Factors critical to the success of the project

There are a number of important factors that led to the successful completion of the project, including:

- expertise of the team members
- good channels of communication
- involvement of stakeholders in all aspects of the project.

2.6.1. Expertise of the team members

The project team comprised experts in software development, teaching and learning, and clinical experience in pharmacy. The software development team had a clear understanding of the virtual patient and its ultimate use. This enabled them to develop a software system with the desired features. The clinical team all had teaching experience in relevant areas and contributed to the development of the clinical cases and the communication decision tree. The clinical team also had a clear understanding of the desired learning outcomes that assisted with the development of the feedback process, and the appropriate assessment of the virtual patient.

2.6.2. Good communication channels

Several meetings of the development team were held. The entire project team met face-to-face on two occasions. The IT and clinical teams met frequently and separately, to work on the software development and evaluation phases respectively. These were face-to-face meetings or teleconferences. Dr David Newby and Dr Peter Summons were key in providing conduits between the IT and clinical teams and had frequent discussions to ensure each group had input into both phases of the project. This regular communication aided quick and effective decision-making, but also ensured that the development of both the software and the decision algorithms were complementary.

2.6.3. Involvement of stakeholders in all aspects of the project

The creation of the reference committee, which involved key pharmacy academics, representatives of the pharmacy profession, and experts in teaching and learning, ensured the final product met the need of students, had a sound pedagogical basis, and addressed the professional training of pharmacy students. Importantly, students were involved in several stages of the project. They were involved in the alpha-testing of the software and the creation of a bank of questions as part of the development of the lexicon for the software, and they were critical to the final evaluation of the software. The participation of the students was an excellent way of ensuring that the program would be able to operate effectively and meet the needs of students for communication experience and feedback.



2.7. Factors that impeded the project

A number of elements hampered the project including:

- knowledge of the students involved in the evaluation phase
- poor response rates to the evaluation phase
- hardware requirements for the software
- issues with software development
- inter-university transfer of funding.

2.7.1. Knowledge of the students involved in the evaluation phase

At all sites, final year students were recruited for the evaluation phase. In hindsight, these students may have had well-developed communication skills already and, therefore, the additional feedback provided by the program may not have added very much to their learning. If students in the first or second year in the bachelor of pharmacy programs had been used, greater impact of the software may have been able to be detected following interaction with the program.

2.7.2. Poor response rates to the evaluation phase

The response rates at each of the partner universities were lower than the team had originally anticipated. This may be in part because of the structure of the programs at each university. For example, at Monash University, the majority of final year students are on clinical rotation and not on campus. This significantly reduced the pool of students available. There are 220 students in fourth year at Monash University; however, clinical placements occur during most of first semester meaning that only 20 per cent of students (those who had a 'bye' from placements) were available to take part in the project evaluation. Similarly, at CSU, 110 students were invited to participate, but only 24 of those students were actually based in Orange (where the assessments took place). The use of final year students may have also impacted on their desire to take on extra-curricular activities. By the final year, students are very focused on finishing and may have not wanted any additional work to impact on this. Low participation rates may also reflect a lack of understanding by the students as to the potential benefits of this largely unknown tool for improving their communication skills.

2.7.3. Hardware requirements for the virtual patient software

The virtual patient software was developed based on a Windows application using Windows XP as the operating system. Over the time of the project, and unbeknownst to the project team, decisions were made at some partner universities to change the hardware used in some teaching laboratories. For example, at The University of Newcastle, it was decided to change to Macintosh computers running Windows 7 over the summer break in 2009/2010 (just prior to the evaluation phase). The result was that the software did not work initially. At other sites, there was the need to use hired laptops with certain specifications to run the program, for which the original software had not been developed. This required different versions of the virtual patient program to be built and tested – some with known limitations. The need for high-capacity hardware resulted in the program running very slowly at both Monash and Charles Sturt Universities, thus affecting the ability of students to appropriately interact with the virtual patient.



2.7.4. Issues with the software development

There were integration problems of software modules between teams at different universities. The language chosen for the integrated program was Java so that it was portable. However, the local implementations of Java, e.g. using NetBeans for the assessment and reasoning module, resulted in many problems with the implementation on different monitor resolutions, software operating system platforms and hardware (Macintosh and IBM computers).

As the programming relating to the sequence of interview questions and answers was not completed as part of the software development, the probabilistic reasoning techniques for student question recognition by the virtual patient program were not effective.

There was no initial ontology or transcripts of interview question/answers. This resulted in a lack of a training set and therefore an inability to apply any sophisticated artificial intelligence techniques, such as neural networks, to the recognition of sample data.

As noted earlier, different resources (hardware and software) in assessment sites at different universities required different versions of the virtual patient program to be built and tested – some with known limitations.

Other issues included:

- lack of synchronisation between the speech and the lip movements
- generation of facial expressions restricted to 3-D lips and two expressions – smile and normal
- different speech engines for the male and female voice meant that the female voice (generated by the Microsoft commercial speech engine) did not work in all the operating system environments that had to be implemented at the different universities.

2.7.5. Difficulties in transferring funding between universities

Inter-university funding policies resulted in funds not being released from the primary institution to recruit and pay staff at other institutions for more than six months into the project. This contributed to a significant delay in starting the project.



3. Dissemination

A number of dissemination strategies have been used:

- the work has been published and presented at various IT and pharmacy academic fora
- a workshop was conducted with pharmacy academics to introduce them to the software, and
- the reference committee provided the opportunity to seed the project in the minds of key members of the profession.

3.1. Publications and conference presentations

3.1.1. ACIS Conference Presentation 2009

Dr Peter Summons presented an E1 conference paper in the proceedings of the leading Australasian Information Systems conference:

Summons, PF, Newby, D, Athauda, R, Park, M, Shaw, P, Pranata, I, Jin, JS, Xu, YD (2009) 'Design strategy for a scalable virtual pharmacy patient' *ACIS09 Proceedings of the 20th Australasian Conference on Information Systems*, Melbourne, Dec, pp 96-110.

3.1.2. Poster presentations at ALTC workshops and ATN Assessment Conference

Posters of the project were presented at Carrick/ALTC Assessment forums in 2008 and 2009. In 2009 the poster was also presented at the ATN Assessment conference in Melbourne.

3.1.3. Technology showcase at Pharmacy Education Symposium

Dr David Newby was invited to present as part of a Technology Showcase at the Monash Pharmacy Education Symposium in Prato, Italy in July 2009. The showcase featured a number of technological teaching tools and, although the timing of the session resulted in only a small number of participants taking part, it provided an opportunity to demonstrate the virtual patient to pharmacy academics from around the world representing 27 universities and 14 pharmacy organisations.

3.1.4. Workshop with pharmacy academics

A workshop was organised as part of the Australasian Pharmaceutical Sciences Association conference in Hobart in December 2009. Twenty-one pharmacy academics registered and 15 academics attended the workshop. The outcomes of the workshop are outlined in Section 5.2. At the end of the workshop, attendees were invited to sign up to receive access to the software once the project was completed. Nine academics, representing six universities in Australia and one in New Zealand, requested the first release of the software. This represents nearly half the pharmacy programs in Australia and New Zealand.

3.1.5. Planned publications and presentations

There are plans to publish the outcomes of the project in both IT and pharmacy education



journals once the project is completed. Dr David Newby has been asked by the School of Pharmacy of The University of Queensland to present at their seminar series in October 2010.

3.2. Dissemination of the final software

The software will be made available on a server for downloading, along with the appropriate manuals. To track usage of the software, potential users will be directed to make contact with one of the research team (Dr David Newby), who will then provide the web link and appropriate username/password to download the software. As identified above, we will make the software available first to those academics who indicated they would like to use the software from the workshop held in December 2009.



4. Linkages

The broad applicability of this project with its focus on communication skill development has evoked interest in its application in other pharmacy education settings, as well as an inter-professional learning (IPL) context. Similar, and often identical, challenges and drivers face all health professionals in preparing their students for competent interaction with patients and their carers, as well as with other health professionals. The flexibility of this project allows for development of specific content to meet the learning needs of varied student populations with the advantages of a consistent platform for development and delivery enhancing the experience of both students and educators. In light of this, Monash University is exploring the incorporation of the software from this project in a new IPL project that will use our virtual patient to explore the challenges of providing care for older people with multiple medications, with medical and pharmacy students working together.

Key outcomes of this project will be a reflection on the history-taking of each discipline and the nature of the information gathered by each group. This virtual patient scenario is currently being developed in detail for integration with the visual dimension of the virtual patient for introduction into the curriculum in 2011. It is hoped this project will provide a model for the development of further IPL elements for the health sciences at Monash, and this virtual patient will provide a platform for this wider use. This is possible due to the transferability of the software, as it was designed to be expanded and modified easily to any situation involving history-taking and other professional communication activities and, as such, is not pharmacy-specific.



5. Evaluation

The software was evaluated in three ways:

- formative evaluation (alpha testing) of the software before final evaluation
- evaluation by pharmacy academics at the APSA workshop
- final evaluation in a randomised controlled trial.

5.1. Alpha testing of the software

5.1.1. Methods

All students in the final year of the master of pharmacy program at The University of Newcastle were invited to test the software in November 2009. Each was sent an information sheet and consent form. The students were chosen as they were about to finish the program and would not be involved in the final evaluation phase in 2010. All students who consented to participate attended a session with the virtual patient. The students were asked to use the virtual patient, and, at the end of their session, took part in a focus group discussion about the software. The alpha testing phase was approved by the Human Research Ethics Committee of The University of Newcastle, the Monash University Human Research Ethics Committee, and the Charles Sturt University Human Research Ethics Committee.

5.1.2. Results

Six students agreed to take part, and five students attended the session. The results of the focus group discussion indicated that the students thought it was 'fun' and 'of our age'. There was some frustration with the synthesised voice and some difficulty in the software understanding their questions. Solutions recommended by the participants to the problems with recognising the questions included the use of a drop-down box with suggested questions if the virtual patient continues not to understand a particular question. When asked what other features they thought would be useful, the participants identified providing a transcript of the conversation so they could see the questions and answers in order. Other comments included that "it encourages a more systematic approach in asking questions..." and "...it's a good idea...definitely would help considering we don't do that much kind of tutorials like this..."

5.1.3. Outcome

As a result of the alpha testing, a number of changes were made to the software including using the unmatched questions from the session to expand the vocabulary, and the addition of a report with the transcript of the conversation.

5.2. Evaluation by pharmacy academics

5.2.1. Methods

As described in Section 3, a workshop was organised prior to the annual Australasian Pharmaceutical Science Association (APSA) in Hobart in December 2009. Twenty-one academics enrolled in the pre-conference workshop, and 15 attended the workshop. The participants were given a presentation on the background to the virtual patient followed by time to use the virtual patient in both student and administrator mode. After using the



virtual patient, participants were asked to complete a feedback form. Once the session was finished, the database of unmatched questions, i.e. those questions not recognised by the software, was analysed to look at the rate of matching.

5.2.2. Results

Feedback forms were completed by 10 of the participants.

What the participants liked about the virtual patient:

Participants liked the feedback provided to the students, and that students could practise as much as they liked in their own time. Participants also liked that it allowed students to reflect on how they interacted with the virtual patient. Overall, the comments were very positive, such as:

“This is a fabulous student resource.”

“A fantastic tool.”

What frustrated the participants about the virtual patient:

The voice, particularly its computerised monotone, was a common criticism. Another problem was the difficulty in understanding the questions. However, many participants recognised that this would improve as the databank expanded. The inability to talk colloquially was also identified as a problem by one participant.

What features would participants like for the virtual patient:

Some of the future improvements/features identified by the participants included:

- ability to ask clarifying questions
- ability to show physical conditions such as skin conditions
- ability to give feedback on the order of the questions
- a more expressive face
- seeing a list of questions asked during the session.

What the participants thought of the scenario:

Participants generally thought the scenario (a cough) was a good one, and considered it realistic and appropriate. The participants felt that any minor illness presentation could be used as a scenario. One participant suggested developing a scenario around a prescription medicine.

When would the participants use the virtual patient in their teaching:

Participants identified a range of times in a pharmacy program that they would consider using the virtual patient. Some would use it early, e.g. first year, to practise history-taking by learning the types of questions to ask. Others would use it later, e.g. final year, to simulate real practice. It was also suggested that the scenarios could progress from simple cases early on, to complex cases by the final years. Some participants suggested using the virtual patient for practice prior to assessments such as Objective Structured Clinical Examinations (OSCEs), and others would use it prior to experiential placements.



What the participants thought of the administrator mode:

Many of the participants did not use the administrator mode because they were using the software in student mode for most of the session. Those who used it found it easy to navigate around the administrator mode. The participants also generally liked the available reports.

Unmatched questions:

The database of unmatched questions indicated a matching rate of approximately 50 per cent for this trial with pharmacy academics.

5.2.3. Outcomes

Given the short time from the workshop to the final evaluation phases, it was not possible to address all of the issues raised by the participants. In response to one of the issues raised, a reporting capability to provide a transcript of all questions asked and virtual patient answers given as responses to a specific student assessment was added to the system to provide students with more feedback on their assessment attempt.

The ability of the system to provide some feedback on the appropriate sequencing of questions and answers was added to the system reasoning. This feature was not used for the final evaluations due to the length of time it would have taken to formulate and integrate the rules into each assessment scenario.

It was decided to focus primarily on improving the system's question recognition. To do this, the software was augmented with a filter looking for certain key words to try and match with possible questions. Keyword matching was added only as a secondary matching attempt if the initial data sentence match failed.

5.3. Final evaluation phase

The final evaluation phase was a randomised controlled trial at the three partner universities (The University of Newcastle, Monash University and Charles Sturt University).

5.3.1. Methods

Recruitment and randomisation

All students studying in the final year (Year 2 in the Master of Pharmacy at The University of Newcastle, and Year 4 in the Bachelor of Pharmacy at Monash and Charles Sturt Universities) were invited to take part. Students were sent an information sheet and consent form. Those students who consented to take part were randomly assigned to either the intervention or control group. Randomisation was completed using computer-generated block randomisation (block sizes of 4) at each university. The study protocol was approved by the Human Research Ethics Committee of The University of Newcastle, the Monash University Human Research Ethics Committee, and the Charles Sturt University Human Research Ethics Committee.

Intervention

Three scenarios were developed by the clinical team academics (cough, constipation and gastro-oesophageal reflux). For each scenario there were three levels of severity (mild, moderate and severe). The mild level was a simple presentation of the condition that



would be amenable to self-treatment. The moderate level was still generally amenable to self-treatment, but was border line on needing referral. The severe level was a presentation that required referral to a medical practitioner, e.g. was not a self-limiting condition, was probably caused by a prescribed medicine. Thus, there were nine scenarios in total. Students assigned to the intervention group were asked to attend three sessions with the virtual patient over a one-week period. At the first session, students undertook a training scenario based on a simple headache to familiarise themselves with the program. At each session, students interacted with a patient with each of the three conditions at one of the three levels. For example, at the first session they may have seen a patient with mild cough, severe constipation, and mild gastro-oesophageal reflux. The order and severity were randomly assigned. By the end of the third session, students had interacted with all nine scenarios.

Outcomes

The study examined three main outcomes:

- changes in self-reported confidence in communication skills
- improvements in managing minor illnesses
- views/opinions on the use of the virtual patient as a learning tool.

In addition, the databases within the software were analysed to look at the time taken by each student with the virtual patient, and the rate at which questions matched.

Changes in self-reported confidence in communication

Both intervention and control groups undertook a baseline assessment of their confidence in communication skills relating to managing minor illnesses using an online, self-administered questionnaire (Appendix 2). The baseline survey also gathered some simple demographic information including ethnicity, familiarity with computers, and whether the student worked in a pharmacy. At the end of the study, participants in both groups were asked to complete another evaluation of their perceived confidence, using the same instrument as the baseline evaluation.

Improvements in managing minor illnesses

Approximately one week after the intervention group had sessions with the virtual patient, students in both groups underwent an Objective Structured Clinical Evaluation (OSCE). The OSCE involved the students interacting with an actor, who pretended to have a minor illness. The student interviewed the actor, reached a diagnosis, and then selected an appropriate treatment. The sessions were videotaped and the tapes assessed separately by two examiners.

Views/opinions on the use of the virtual patient as a learning tool

The students' views and opinions about the virtual patient in the intervention arm were elicited in two ways. First, additional questions were asked in the final survey for participants in the intervention arm about the students' perceptions of the virtual patient as a learning tool, and how realistic they thought the virtual patient was (Appendix 3). The realism was assessed using a modified version of the Maastricht Assessment of Simulated Patients (Wind et al., 2004). Second, students in the intervention group were invited to take part in a focus group discussion. The topics of the focus group discussion included the positive and negative aspects of the program, the authenticity of the software, and how well it met the students' needs (Appendix 4).

An overview of the study design is outlined in Figure 5.1.



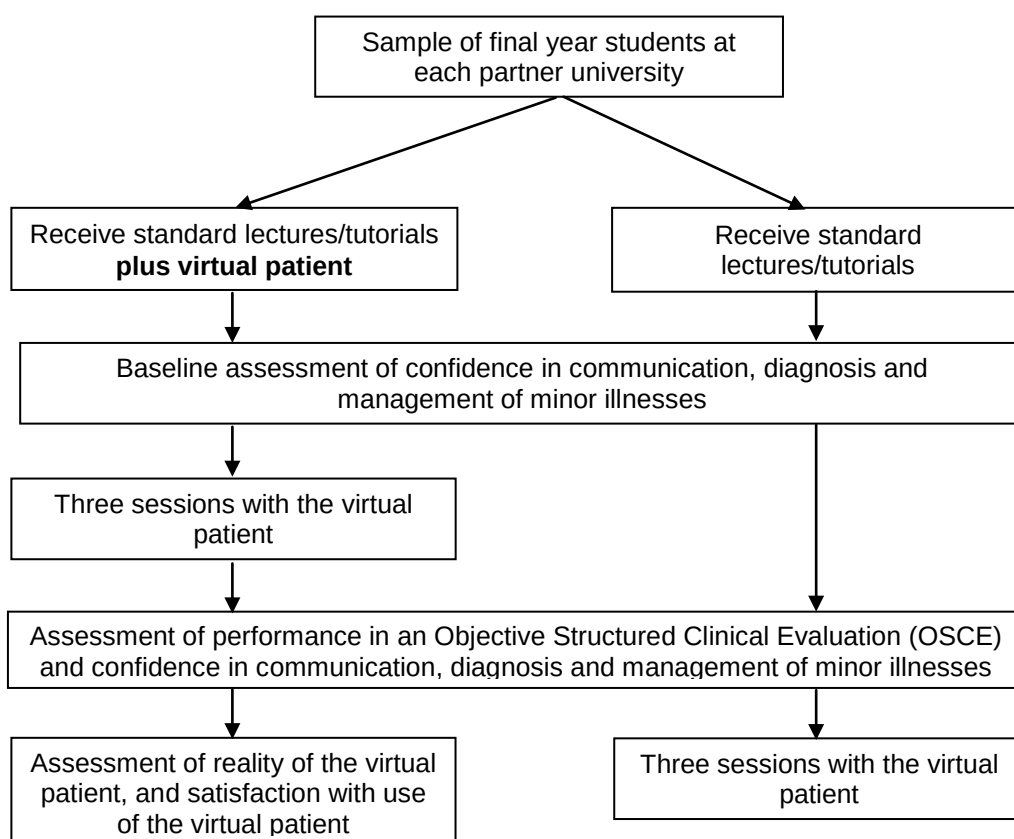


Figure 5.1: Summary of the final evaluation design

5.3.2. Analysis

The baseline characteristics and baseline self-reported confidence were compared between the intervention and the control arms across the three sites. For the statements relating to their confidence in communication, the proportion of students who either agreed or strongly agreed with the statement was reported. Negatively worded statements relating to self-reported confidence were re-coded into positive responses, e.g. for the statement “I need more practice in history-taking” the proportion of students disagreeing/strongly disagreeing to this statement was reported. Given the small sample size, a descriptive analysis is presented.

Changes in self-reported confidence in communication

The average baseline survey responses for the self-reported confidence were also compared between intervention and control arms. Where participants answered both the baseline and the final surveys, the change between surveys was analysed. To do this, responses were coded as positive, i.e. the student was more positive about their confidence in the final survey than the baseline survey, neutral (no change from baseline to final survey) or negative (final survey was less positive than the baseline survey).

Improvements in managing minor illnesses

Two assessments of the OSCE were undertaken. The first involved grading the student out of 5 (1= poor and 5=excellent) on each of the areas of history-taking, choice of management, and counselling, and then giving a global assessment of the OSCE out of 10 (Appendix 5). The grading was based on a single viewing of the video of the OSCE, i.e. the marker was not allowed to rewind or pause the video) to simulate the usual marking conditions of an OSCE. The second assessment involved counting how many history-taking questions were asked using the marking guide. When doing this the markers could pause and rewind the video until they were satisfied they had counted all



history taking questions. Two markers independently graded each student and then the markers met and discussed their results. Where possible, differences in their marks were resolved by consensus, otherwise an average of the two marks was taken.

Opinions on the use of the virtual patient as a learning tool

The results of the questions in the final survey relating to the views of the patient as a learning tool and its realism were analysed comparing international and domestic students, and comparing students at Newcastle to those at the partner institutions. The comparison of international and domestic students was based on the possibility that international students may have more difficulties getting the virtual patient to understand their questions compared to domestic students, which could lead to frustration and a negative attitude towards the virtual patient. The comparison between Newcastle and the other sites was undertaken because there were significant problems with the rollout at Monash and CSU, and this could have led to increased dissatisfaction with the software. Further, the Newcastle program is a graduate entry program, compared to undergraduate programs at Monash and CSU.

Focus groups

The focus groups were digitally recorded and the sessions transcribed verbatim. The transcripts were analysed thematically using HyperRESEARCH software (version 2.8.3) to aid with the analysis("HyperRESEARCH Qualitative Analysis Tool," 2009).

5.3.3. Results

Invitations were sent to 83 students at The University of Newcastle, 220 at Monash University, and 110 at CSU. Thirty-four students at The University of Newcastle, 32 at Monash University, and seven at CSU consented to take part and were randomised. Three students from Newcastle, two students from Monash, and one student from CSU subsequently withdrew from the study, giving a final sample of 67 across the three sites who completed at least one aspect of the study (Figure 5.2).



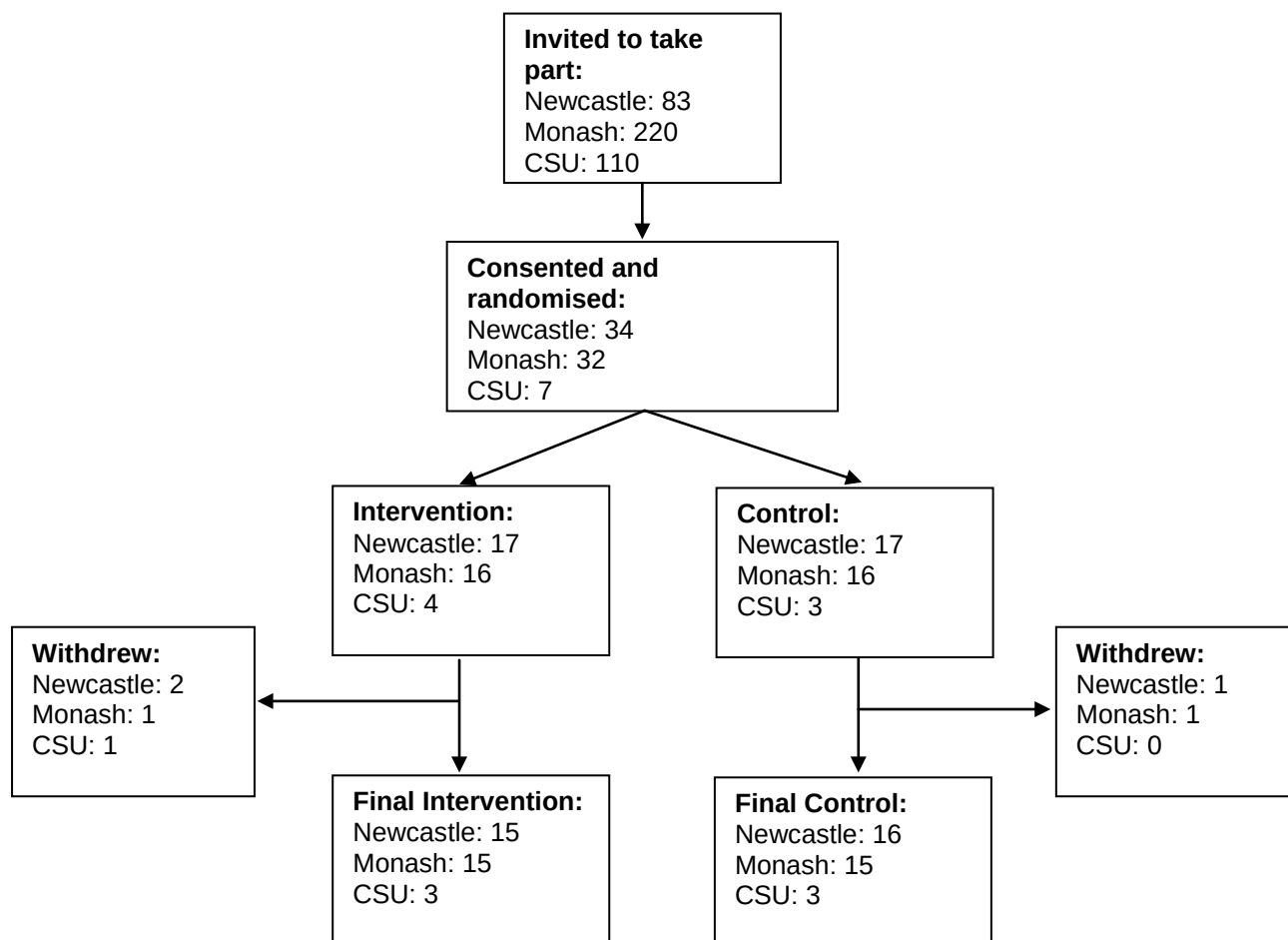


Figure 5.2: Flow of participants

Sixty-four students completed the baseline questionnaire. The baseline demographic characteristics were reasonably similar across the three sites (Table 5.1), and for the intervention and control groups (Table 5.2). The main difference was that none of the participants from CSU were international students.

Table 5.1: Demographic characteristics of participants at each site

	CSU (n=6)	Monash (n=27)	Newcastle (n=31)
Age (mean, years)	24	22	25
Males (n,%)	1 (17)	9 (33)	9 (29)
Born overseas (n,%)	3 (50)	16 (59)	15 (48)
Parents born overseas (n,%)	5 (83)	23 (85)	17 (55)
LOTE ^a at home (n,%)	3 (50)	13 (48)	13 (42)
International student (n,%)	0 (0)	12 (44)	11 (36)
Ever worked in pharmacy (n,%)	4 (67)	23 (85)	14 (45)
Worked greater than 1 year in pharmacy (n,%)	2 (33)	16 (59)	8 (26)
Average time in pharmacy (months)	26	20	16

a. LOTE: Language other than English



Table 5.2: Demographic characteristics of participants by allocation

	Intervention (n=30)	Control (n=34)	Total (n=64)
Age (mean, years)	23	24	24
Males (n,%)	9 (30)	10 (29)	19 (30)
Born overseas (n,%)	17 (57)	17 (50)	34 (53)
Parents born overseas (n,%)	22 (73)	23 (68)	45 (70)
LOTE ^a at home (n,%)	14 (47)	15 (44)	29 (45)
International student (n,%)	11 (37)	12 (35)	23 (36)
Ever worked in pharmacy (n,%)	19 (63)	22 (65)	41 (64)
Worked greater than 1 year in pharmacy (n, %)	11 (37)	15 (44)	26 (41)
Average time in pharmacy (months)	15	21	18

a. LOTE: Language other than English

Changes in self-reported confidence in communication

Sixty-four students completed the baseline survey, and 45 completed the final survey, evaluating their self-reported confidence in communication skills. In the intervention group, the final evaluation showed a trend to an increase in confidence across all areas with the exception of the questions “I always get all the relevant information I need from a patient” and “My general communication skills are very good” (Table 5.3). By contrast, the control group reported small decreases in self-reported confidence for three of the questions and no change for two of the questions, with improvements for four questions. However, given the smaller number who answered the final questionnaire, these changes are difficult to interpret.

Table 5.3: Baseline and final reported self-confidence in areas of communication for the intervention and control groups

	Agree/Strongly Agree (n, %)			
	Intervention		Control	
	Baseline (n=30)	End (n=23)	Baseline (n=34)	End (n=22)
I am confident in my ability to take a patient history	13 (43)	13 (57)	16 (47)	8 (36)
I am confident speaking with patients	21 (70)	17 (74)	21 (62)	14 (64)
I (don't) need more practice in history taking ^a	2 (10)	3 (13)	1 (3)	1 (5)
My general communication skills are very good	20 (67)	13 (57)	18 (53)	9 (41)
I always get all the relevant information I need from a patient	8 (27)	4 (17)	4 (12)	4 (18)
Medication histories are easy for me to obtain	12 (40)	12 (52)	11 (32)	7 (32)
I understand when to use open-ended questions	19 (63)	17 (74)	23 (68)	15 (68)
I understand when to use closed-ended questions	18 (60)	17 (74)	20 (59)	15 (68)
I (don't) find it hard to give advice on how to use a medicine ^a	16 (53)	14 (61)	16 (47)	8 (36)

a. Reverse scored during analysis – interpret as described here

Forty-three (67 per cent) participants completed both a baseline and final survey. There was no consistent difference between the intervention and control groups, with similar proportions showing positive changes from baseline in each group (Table 5.4). However, the small sample size makes comparison difficult.



Table 5.4: Proportion of participants who showed a positive change in their confidence from baseline to the final survey

	Positive change (n, %)	
	Intervention (n=22)	Control (n=21)
I am confident in my ability to take a patient history	3 (14)	3 (14)
I am confident speaking with patients	3 (14)	4 (19)
I (don't) need more practice in history taking ^a	7 (32)	4 (19)
My general communication skills are very good	0 (0)	4 (19)
I always get all the relevant information I need from a patient	4 (18)	7 (33)
Medication histories are easy for me to obtain	5 (23)	6 (29)
I understand when to use open-ended questions	5 (23)	2 (10)
I understand when to use closed-ended questions	5 (23)	5 (24)
I (don't) find it hard to give advice on how to use a medicine ^a	7 (32)	5 (24)

a. Reverse scored during analysis – interpret as described here

Improvements in managing minor illnesses

Twenty-six students from Newcastle, 21 from Monash, and four from CSU took part in the OSCE after the intervention period. All four students from CSU were in the intervention group; their results were not available at the time of analysis and are not included here.

There was no difference in average or median scores for their overall performance (rated out of 10) for students assigned to the intervention or control groups (average intervention = 4.5 [SD 1.87], control = 4.3 [SD 1.98]; median intervention = 5, control = 4). There was a small difference in overall scores between the two study sites, with overall scores for students from Newcastle slightly higher than those from Monash (average Newcastle 4.9 vs average Monash 3.7).

Overseas students, regardless of study group, had lower mean scores than domestic students (3.5 vs 5.1), and lower median scores (4.0 vs 5.0). However, there were no differences when those in the intervention or control groups were compared (Table 5.5).

Table 5.5: Comparison of overall scores out of 10 for international and domestic students for overall performance in the OSCE

	Intervention (mean, SD)	Control (mean, SD)
International students	3.8 (2.07)	3.3 (1.80)
Domestic students	5.1 (1.58)	5.0 (1.82)

Examining the scores given for their history-taking (out of 5), again there were no significant differences between the intervention and control students (average intervention = 2.3 [SD 0.85], control = 2.0 [SD 0.82]).

Again, international students tended to have lower scores than domestic students for their history-taking (Table 5.6).

Table 5.6: Comparison of scores out of five for international and domestic students for history-taking performance in the OSCE

	Intervention (mean, SD)	Control (mean, SD)
International students	1.8 (0.82)	1.8 (0.72)
Domestic students	2.7 (0.66)	2.2 (0.86)



Overall there were generally no differences in the number of questions asked when taking a history between the intervention and control groups (Table 5.7). The main differences were that students in the intervention arm were more likely to ask about other symptoms (70 per cent vs 39 per cent), about allergies (57 per cent vs 30 per cent), and about whether the patient could be pregnant (61 per cent vs 48 per cent), whereas students in the control group were more likely to ask if the patient had tried anything (65 per cent vs 48 per cent) and why Lomotil® (the medicine the patient was asking for) was preferred (65 per cent vs 52 per cent).

Overall, international students were less likely to ask questions when taking a history, compared with domestic students (average 7.2 out of 17 questions for international students compared with 8.9 out of 17 for domestic students) irrespective of the group they were assigned to.

Table 5.7: Comparison of questions asked by students in the intervention and control arms

	Asked question (n, %)	
	Intervention (n=23)	Control (n=23)
Asks who is it for	20 (87)	19 (83)
Asks for description of symptoms	18 (78)	17 (74)
Asks the duration of symptoms	21 (91)	22 (96)
Asks if they have had this recently	6 (26)	4 (17)
Asks what their normal bowel habits are like	1 (4)	2 (9)
Asks when the diarrhoea occurs (e.g. only morning)	0 (0)	0 (0)
Asks if they have changed their diet	13 (56)	14 (61)
Asks if there are there any other symptoms	16 (70)	9 (39)
Asks if they have tried anything to treat it	11 (48)	15 (65)
Asks for any other medical conditions	15 (65)	12 (52)
Asks about allergies	13 (57)	7 (30)
Asks what medications are they taking	17 (74)	17 (74)
Asks whether they have been overseas recently	5 (22)	8 (35)
Checks they are able to drink things and keep it down	4 (17)	4 (17)
Checks if they are possibly pregnant	14 (61)	11 (48)
Checks if they are possibly lactating	7 (30)	8 (35)
Asks why Lomotil® was preferred	12 (52)	15 (65)

Survey of opinions on the use of the virtual patient as a learning tool

Twenty-two participants (73 per cent) in the intervention arm answered the questions relating to their views on using the virtual patient in the final survey. The majority agreed or strongly agreed, with most of the positive statements about the software (Table 5.8). However, fewer participants stated they enjoyed using the program (23 per cent), or that they learnt a systematic way of asking questions (46 per cent).

With regard the appearance of the virtual patient, respondents were generally negative, in particular with regard to how the virtual patient answered questions, and the voice (Table 5.9). However, analysis of the responses for domestic versus international students indicated that domestic students were overall more positive about the virtual patient than the international students (Tables 5.10 and 5.11).

Comparisons of results from Newcastle versus the other two sites indicated Newcastle students appeared to be more positive about using the virtual patients than students at



other sites (Tables 5.12 and 5.13).

Students who had worked less than a year in a pharmacy, or not at all, tended to indicate more frequently that they felt the virtual patient better prepared them to care for patients and make a diagnosis, compared to those who had worked for more than a year (60 per cent vs 45 per cent and 70 per cent vs 56 per cent agreeing/strongly agreeing respectively). In particular, they felt it helped them identify areas of their communication that they could work on (100 per cent vs 56 per cent agreeing/strongly agreeing), and that using the virtual patient would improve their confidence with real patients (90 per cent vs 56 per cent agreeing/strongly agreeing).

Table 5.8: Agreement with statements regarding the virtual patient from all students in the intervention arm

	Agree/Strongly agree	
	N	%
I enjoyed using the program	5	23
I would use the program frequently if it was available	12	55
Software instructions were easy to follow	14	64
The program was too slow to respond	16	73
I needed to learn more about computers before I could use the program	1	5
The background was distracting	1	5
The program as a whole was difficult to understand	5	23
The virtual patient improved my learning	15	68
The novelty of the program made me want to learn	13	59
The program got in the way of my learning	6	27
Practicing with the virtual patient will improve my confidence with real patients	15	68
The feedback I received was helpful in enhancing my diagnostic reasoning skills	18	83
The case was not at the appropriate level of difficulty for my level of training	1	5
Using the virtual patient helped me...		
understand how to take a patient history	14	64
identify my strengths in taking a history from a patient	17	77
identify my weaknesses in taking a history from a patient	17	77
identify areas of communication that I could work on	16	73
learn a systematic way of asking questions	10	46
After using the virtual patient, I feel better prepared to...		
care for real-life patients with these complaints	11	50
make a diagnosis in a real-life patient with these complaints	14	64
select the appropriate management for a patient with these complaints	13	59



Table 5.9: Agreement with statements about the reality of the virtual patient from all students in the intervention arm

The virtual patient...	Agree/Strongly agree	
	N	%
appeared authentic	9	41
acted like a real patient	10	46
appearance fitted the role	14	64
simulated physical complaints unrealistically	8	36
answered questions in a natural manner	6	27
voice had a good pitch	10	46
voice was difficult to understand	12	55
appeared to withhold information	12	55
did not understand my questions	20	91
answers to my questions were confusing	6	27
I felt I was making decisions as a pharmacist would make in real life	15	68
I felt I was the pharmacist looking after this patient	13	59

Table 5.10: Agreement with statements regarding the virtual patient for domestic versus international students

	Agree/Strongly agree (n,%)	
	Domestic (n=13)	International (n=8)
I enjoyed using the program	5 (39)	0 (0)
I would use the program frequently if it was available	8 (62)	3 (38)
Software instructions were easy to follow	10 (77)	4 (50)
The program was too slow to respond	10 (77)	5 (63)
I needed to learn more about computers before I could use the program	0 (0)	1 (13)
The background was distracting	1 (8)	0 (0)
The program as a whole was difficult to understand	2 (15)	2 (25)
The virtual patient improved my learning	11 (85)	4 (50)
The novelty of the program made me want to learn	8 (62)	5 (63)
The program got in the way of my learning	2 (15)	3 (38)
Practicing with the virtual patient will improve my confidence with real patients	9 (69)	6 (75)
The feedback I received was helpful in enhancing my diagnostic reasoning skills	12 (92)	6 (75)
The case was not at the appropriate level of difficulty for my level of training	0 (0)	1 (13)
Using the virtual patient helped me...		
understand how to take a patient history	11 (85)	2 (25)
Identify my strengths in taking a history from a patient	12 (92)	4 (50)
identify my weaknesses in taking a history from a patient	11 (85)	5 (63)
identify areas of communication that I could work on	10 (77)	6 (75)
learn a systematic way of asking questions	7 (54)	3 (38)
After using the virtual patient, I feel better prepared to...		
care for real-life patients with these complaints	8 (62)	3 (38)
make a diagnosis in a real-life patient with these complaints	10 (77)	3 (38)
select the appropriate management for a patient with these complaints	9 (69)	4 (50)



Table 5.11 Agreement with statements about the reality of the virtual patient for domestic versus international students

The virtual patient...	Agree/Strongly agree (n,%)	
	Domestic (n=13)	International (n=8)
appeared authentic	8 (62)	1 (13)
acted like a real patient	8 (62)	2 (25)
appearance fitted the role	11 (85)	2 (25)
simulated physical complaints unrealistically	4 (31)	3 (38)
answered questions in a natural manner	5 (38)	1 (13)
voice had a good pitch	7 (54)	3 (38)
voice was difficult to understand	7 (54)	4 (50)
appeared to withhold information	6 (46)	5 (63)
did not understand my questions	12 (92)	7 (88)
answers to my questions were confusing	5 (38)	0 (0)
I felt I was making decisions as a pharmacist would make in real life	11 (85)	3 (38)
I felt I was the pharmacist looking after this patient	9 (69)	3 (38)

Table 5.12: Agreement with statements regarding the virtual patient for Newcastle versus other sites

	Agree/Strongly agree (n,%)	
	Newcastle (n=10)	Other sites (n=12)
I enjoyed using the program	4 (40)	1 (8)
I would use the program frequently if it was available	5 (50)	7 (58)
The Virtual Patient improved my learning	8 (80)	7 (58)
The novelty of the program made me want to learn	7 (70)	6 (50)
The program got in the way of my learning	2 (20)	4 (33)
Practicing with the Virtual Patient will improve my confidence with real patients	9 (90)	6 (50)
Software instructions were easy to follow	6 (60)	8 (67)
The program was too slow to respond	4 (40)	12 (100)
I needed to learn more about computers before I could use the program	0 (0)	1 (8)
The background was distracting	1 (10)	0 (0)
The program as a whole was difficult to understand	2 (20)	3 (25)
The feedback I received was helpful in enhancing my diagnostic reasoning skills	9 (90)	9 (75)
The case was not at the appropriate level of difficulty for my level of training	0 (0)	1 (8)
Using the virtual patient helped me...		
understand how to take a patient history	7 (70)	7 (58)
identify my strengths in taking a history from a patient	9 (90)	8 (67)
identify my weaknesses in taking a history from a patient	8 (80)	9 (75)
identify areas of communication that I could work on	8 (80)	8 (67)
learn a systematic way of asking questions	5 (50)	5 (42)
After using the virtual patient, I feel better prepared to...		
care for real life patients with these complaints	6 (60)	5 (42)
make a diagnosis in a real life patient with these complaints	7 (70)	7 (58)
select the appropriate management for a patient with these complaints	7 (70)	6 (50)



Table 5.13: Agreement with statements about the reality of the virtual patient for Newcastle versus other sites

The virtual patient...	Agree/Strongly agree (n,%)	
	Newcastle (n=10)	Other sites (n=12)
appeared authentic	5 (50)	4 (33)
acted like a real patient	6 (60)	4 (33)
appearance fitted the role	5 (50)	9 (75)
simulated physical complaints unrealistically	4 (40)	4 (33)
answered questions in a natural manner	4 (40)	2 (17)
voice had a good pitch	4 (40)	6 (50)
voice was difficult to understand	6 (60)	6 (50)
appeared to withhold information	8 (80)	4 (33)
did not understand my questions	9 (90)	11 (92)
answers to my questions were confusing	3 (30)	3 (25)
I felt I was making decisions as a pharmacist would make in real life	6 (60)	9 (75)
I felt I was the pharmacist looking after this patient	6 (60)	7 (58)

Focus group discussions with students who used the virtual patient

Ten students from The University of Newcastle, six students from Monash University, and two students from CSU took part in focus group discussion at each site. The demographics of the participants are described in Table 5.14.

Table 5.14: Demographics of participants in the focus groups at each site

	Newcastle (n=10)	Monash (n=6)	CSU (n=2)
Male (n,%)	1 (10%)	2 (33%)	0 (0%)
Age (median)	22 years	21 years	
Domestic students (n,%)	7 (70%)	4 (67%)	2 (100%)
Works in a pharmacy (n,%)	6 (60%)	6 (100%)	1 (50%)

The focus-group sessions each lasted approximately 30 to 45 minutes.

A number of common themes were identified by participants. These broadly fell into the following areas:

- positive influences on learning from using the virtual patient
- problems and drawbacks with the virtual patient
- what type of students would benefit from using the virtual patient.

In addition, the students identified a number of 'bugs' with the software.

Positive aspects of using the virtual patient

Participants felt that the virtual patient helped them in learning what type of questions they should ask when dealing with requests for help with minor illnesses in a pharmacy. By practising with the virtual patient, several commented that they started to remember to ask questions that they would not have thought of asking before:



I think it helps you practise which questions you should ask.
Student 6 – Monash

...but it really reinforced the questions you needed to ask... like it would really drill into you 'Oh, I forgot to ask that question and I'm continually forgetting to ask that question', that's something I need to address...
Student 3 – Newcastle

So I found that really helpful, because I never would've asked...you know, 'Is the pain radiating?' I never would have thought of that.
Student 2 – CSU

...so, I actually have learnt from that program was to ask if someone was, like if the patient was pregnant. I never thought to ask that in my life.
Student 1 - Monash

Apart from which questions to ask, the participants felt that it helped them be more systematic in how they asked questions:

...the virtual patient would help you go, 'Oh yes, now I've ticked off all the boxes in my head.
Student 3 – Newcastle

I think it would give a really strong base and structure in your style of questioning...
Student 5 - Newcastle

In particular, the participants liked the feedback report that they received at the end of the session. It helped them not only understand why they should ask certain questions, but also helped with learning about diagnosis and management:

...and what I found really good about the program was that they gave you a review afterwards, and it told you what kind of questions you need to ask.
Student 1 – CSU

I think the information they gave you when the diagnosis and treatment like the proper answers were really informative and extensive.
Student 3 – Newcastle

...but I think, like for me the feedback, the assessment page is the best thing...
Student 3 – Monash

Like with the virtual patient it gives you like all the questions that you can ask and like the reason why you should be asking them. So I found that really helpful...
Student 2 – CSU

Some participants felt the software would help improve their confidence in dealing with real patients, although practising with a mixture of virtual and real human patients was important:

I think it teaches you the questions to ask and it gives you... it reinforces the diagnosis and treatment, it's going to give you a lot more confidence to approach patients when we go on clinical practice.
Student 3 – Newcastle



Like with the virtual patient it gives you like all the questions that you can ask and like the reason why you should be asking them...but like in class it's good because you get to practise with real people. So it's different.

Student 2 – CSU

I think it would give a really strong base and structure in your style of questioning but at the same time you can't improve, or you can't replace real communication.

Student 5 – Newcastle

Participants liked the additional time with the virtual patient, compared with real patients, relieving some of the pressure:

You have time to think about it, to think about the response.

Student 2 – CSU

Whereas with this [virtual patient] you can actually take your time and ask it questions...with the scenario you get your time to actually think of all the questions that you'd really like to ask, so it's kind of an ideal situation.

Student 5 – Monash

Participants particularly liked the fact that the virtual patient would give them plenty of opportunities to practise their communication skills:

Yeah, and being able to help me practise as well, I thought it was a really good opportunity.

Student 2 – CSU

I guess overall it's a positive thing for us students to just get decent practice.

Student 9 – Newcastle

Problems and drawbacks using the virtual patient

The participants identified a number of technical issues with the virtual patient, including the voice and the slowness of the software on some computers:

... the responses, it was like there were, more like you could tell it was computer-generated.

Student 2 – CSU

I thought the voice was a bit hard to hear. I actually had to click on replaying the same answer that they say in order to get what they want a few times as well.

Student 6 – Monash

I'm just wondering if where there was a delay because some of the computers were so slow that it would take literally minutes after you've typed your question.

Student 2 - Monash

So time consuming... it's just so slow.

Student 5 – Newcastle

Participants felt there were significant problems with getting the virtual patient to understand the questions that they asked. As a result, they found that they had to change the way they would normally ask a question just to get the software to understand:

And there are times when you can't seem to word the question in the right way [so] that



it will actually understand.

Student 4 – Newcastle

It's like you have to ask it in exactly the right wording for them to understand. 'Cause even the slightest variation it would just be like, 'I don't understand' so it's more frustrating sort of trying to find the right wording to a elicit a response, whereas you wouldn't have that problem in real life.

Student 3 - Monash

Definitely a lot easier, with the first one, once you've learnt how to phrase it.

Student 6 – Monash

I think because you're working to make the computer understand you, you stop being polite, like you have to become very blunt...

Student 4 – Newcastle

When I was typing in the questions, I felt like I had to put it into a grammatically correct sentence, like you couldn't just type in exactly what you would say as if you were colloquially...saying 'Hey, how's it going?'

Student 3 – Monash

Another drawback was the limited visual clues from the virtual patient. This made it difficult for the participants to gauge whether the questions were appropriate or not:

I think maybe if it had more facial expressions it would be good.

Student 1 – CSU

There was no emotion in it [that] you would get in a normal patient.

Student 3 – Monash

It's not going to teach you to read patients' reactions to how to, like, to how you ask the questions, whether it thinks that's an inappropriate question or the way you phrase that was not very polite...

Student 3 – Newcastle

...you don't have that sort of feedback response, you can't say, 'OK, I should have gone through a different path there...'

Student 1 – Newcastle

Students who would benefit from the software

The participants felt that the software could be introduced earlier in the pharmacy program, possibly in the first or second year, if the program was at a simpler 'level':

...you could have different levels of difficulty as well, like, according to, you know, the first and the second year, the knowledge level will be different...

Student 1 – CSU

Oh yeah, probably earlier, yeah, might have been of benefit.

Student 1 – Newcastle

I thought the virtual patient should be started really early when you start doing counselling...Maybe it's good if the virtual patients come in different levels...

Student 5 – Newcastle

It was felt that the software could be particularly beneficial for students who do not work in



a pharmacy and, therefore, do not get to practise these skills regularly:

Yes, because [Student 1] works in a pharmacy and I don't, whereas I have not had enough experience with counselling, so it would help me improve.

Student 2 – CSU

I think for me I don't think I'll change cause I already work in a pharmacy and all the questions... I just did it by knowledge.

Student 4 – Monash

I think that's what the virtual patient does a bit is for the people who haven't worked in pharmacy. Like helps them sort of, for like, if you were to go on placement now you'd probably more confident talking to a real person.

Student 4 – Newcastle

Analysis of the databases from the software

The final recognition rate for questions asked was 62 per cent for domestic students and 52 per cent for international students.

5.3.4. Discussion

Overall, students were positive about using the virtual patient and its impact on their learning. This was despite frustrations with the logistics of slow responses and lack of recognition of some questions. Focus group respondents were clear that, without the technical problems, the acceptability would have rated highly. Many students appreciated the opportunity to undertake clinical reasoning exercises in an unpressured environment, rather than in a role-play with tutors and other students observing, as they could think through a case in their own time, with the case unfolding in response to their own questioning, unlike written case studies.

The majority of students in the focus groups cited the feedback on their performance and the opportunity to practise repeatedly as the most useful features of program. With the unstructured nature of the interface between the student and the virtual patient, the questioning by the student gives a reasonable simulation of clinical reasoning in primary care conditions. Thus, the feedback provided after each scenario is an effective formative assessment, allowing the student to review the positives and negatives of their performance, and then to undertake another scenario in which to apply what they have just learned from the feedback. This feedback loop is a powerful educational tool, which has been recognised for many years as essential for education of all kinds, including pharmacy programs (Johnson, 1978). Immediate feedback, as provided at the end of each scenario, has more impact than feedback after days or weeks, and this has been demonstrated in clinical reasoning in pharmacy (Mehvar, 1999).

Case study scenarios in tutorial or lecture format are generally used as springboards for introducing the relevance of multiple disciplines and, therefore, use an expansive model (Hartzema, 1994). In contrast, the use of scenarios in role-plays for clinical reasoning purposes is to enable students to apply their knowledge of other disciplines selectively, so the structure is one of progressively narrowing down possibilities to arrive at a diagnosis (Seybert, Kobulinsky, & McKaveney, 2008). Many students felt that using the virtual patient had enabled them to develop a firmer structure in history-taking, which facilitated the diagnostic process and improved their confidence in dealing with primary care issues, which are a large part of a community pharmacist's daily role. These outcomes are consistent with the role of virtual patients suggested by Cook and Triola, who reviewed recent literature concerning virtual patients used in health care education (Cook



& Triola, 2009).

Another consistent theme in student feedback was that differing levels of the program be developed for different stages of students, with earlier years using versions with higher levels of guidance to train student in history-taking skills, while later years receive the unstructured version to challenge their clinical reasoning. This was also suggested by the pharmacy academics who trialled the program at the Australasian Pharmaceutical Sciences Association conference in December 2009.

Differences between international and domestic students

In terms of acceptability of, and satisfaction with, the virtual patient program, domestic students overall were more positive than international students. The reasons for the differences between these student groups may be complex. They may be partly due to language issues: some international students had language barriers and sometimes were not sure whether the program did not understand a question due to the programming or because of their English, and this created another level of frustration that was not present for domestic students. Language difficulties are the most likely academic problems for international students to face (Sawir, 2005), so this is not confined to the virtual patient, but may be exacerbated by the synthesised voice. A more natural-sounding voice may help alleviate problems in understanding the program, and better recognition of the question input should alleviate at least some of the language frustration. Another alternative may be an option to turn on suggested questions, after several questions have not been recognised.

There may also be a cultural element. Some international students were from countries with didactic academic cultures, and were not entirely comfortable with the unstructured nature of the virtual patient program. Learning styles of international and domestic Australians may differ markedly (Lashleya & Barronb, 2006; Nguyen, Terlouw, & Pilot, 2006; Wong, 2004), and for the cohort of international students in the pharmacy courses, the unstructured nature of the virtual patient experience, particularly the format of the interface, appeared to be unsettling as they were unsure what was expected of them. Even after completing some scenarios, some students were still uncomfortable with the format, despite technically knowing how to proceed.

Hawthorne has discussed issues of language, culture and learning style as they relate to medical education for international students, and many of the same issues apply to education of pharmacists, particularly those relating to communication skills (Hawthorne, Harry Minas, & Singh, 2004). The aspects of the virtual patient that appeared to be most unsettling for the international students, namely the lack of structure and unpredictability, as well as the difficulty in language, are similar to issues they will face in community pharmacy practice. So, it may be that the virtual patient is providing a more realistic experience than expected, and the difficulties that international students have above those of domestic students are those that they will encounter in actual practice.

Differences between students at Newcastle and students at the other sites

The more positive attitude toward the virtual patient demonstrated by students in Newcastle, compared to the other sites, is most likely due to the software running best at Newcastle. There were significant hardware issues at both Monash and CSU, with the software needing to be installed on computers that did not possess the processing speed of the desktop computers in Newcastle. The main result was that the software ran exceedingly slowly at Monash and CSU and the students' frustrations with this are reflected in their comments from the focus group. The computer requirements to run the program adequately need to be clearly defined and, if possible, brought within the usual



capacity of computers provided by universities for student use. Computer operating capacity will otherwise limit the widespread use of the program.

The slightly higher results in the OSCE in Newcastle compared to Monash are more difficult to explain, given both groups of students were at similar points in their educational programs. However, the differences are generally small (just over one point on a 10-point scale). It was revealed after the completion of the OSCE that the students at Newcastle had undertaken an assessment using a similar clinical scenario (a patient going overseas and wanting something for travellers' diarrhoea) to the one in the OSCE (a patient presenting with diarrhoea) only a few weeks before the OSCE for the evaluation of the virtual patient program. Therefore, there was a possible carry-over effect from the earlier assessment.

Impact on self-reported confidence in communication

There was an overall trend for students who used the virtual patient to report slightly better confidence in communication after using the virtual patient than before. However, this was less apparent for the smaller number of students who answered both the baseline and final survey. An interesting observation was that confidence declined in some areas, in particular in response to the item "My general communication skills are very good".

One explanation for the decline in confidence in some areas is that the final survey was conducted after the students had participated in the OSCEs, and this experience had highlighted deficiencies in their communication skills of which they had been previously unaware. This is consistent with research findings among medical students where some students who were confident of their history-taking and physical examination skills prior to an OSCE were less confident in retrospect (Allen et al., 1998). Confidence in one's own ability to carry out an action or task successfully, or 'self-efficacy' is formed by a complex mix of learning experiences, ongoing performance, persuasion, social influences, and emotions (Mavis, 2001). As the final survey was completed after the OSCE assessment, a format most students were not familiar with, some found it anxiety-inducing. Many students felt they had not done well, so the data on feelings of confidence may reflect feelings about the performance and emotions relating to the OSCE, rather than any impact on self-efficacy by the virtual patient program.

Students participating were in the final year of their respective programs, having completed significant formal education in communication (including history-taking) as well as several experiential placements in which communication skills have been practised and refined. At this stage of their course, many students also work in pharmacies where their communication skills are practised frequently and they have the opportunity to develop confidence. The use of the program earlier in the pharmacy program may therefore be more beneficial in developing students' skills and confidence in communication.

Impact on the management of minor illnesses as measured by the OSCE

Although there were no significant differences found in the overall OSCE scores, the scores for history-taking, and the number of history questions asked, there was a trend for students in the intervention arm, irrespective of whether they were international or domestic students, to score slightly higher than those in the control arm. The lack of significance in this result is due largely to the small number of students who participated. With respect to the low overall scores, this may reflect the fact that this overall score is a mixture of the communication (getting a history) and clinical reasoning (diagnosing and choosing the appropriate management) skills. Given the scenario tested in the OSCE



(diarrhoea) was not the same as any of the virtual patients (cough, constipation and reflux), it was less likely that using the virtual patient would have an influence on the diagnosis and appropriate management in the OSCE. However, as history-taking includes a range of generic questions asked of just about all presentations, e.g. "How long have you had X?", using the virtual patient was expected to have the greatest impact on history-taking. While not showing large differences, the intervention group did appear to do slightly better on the rating of their history-taking than the control group. While the number of questions asked did not differ, there was a trend towards the intervention group asking more generic questions, such as whether the patient had allergies or could be pregnant, compared to the control group.

As this was not an assessment relating to their course marks, students may not have approached the OSCE with the same attitude as if marks were involved. In addition, for some students, e.g. Monash students, this was their first experience of an OSCE and they may not have understood exactly what they should do during the examination, or have been as well prepared.

Role of the virtual patient depending on experience and practice with communication skills in pharmacy

Our results suggest that having a virtual patient available could be particularly beneficial to students with limited experience with, or opportunity to practise, communication skills. This was demonstrated by the comments and feedback from those students who have worked for only a short time, or not at all, in a pharmacy. Therefore, the virtual patient could have a role early in pharmacy training to help with basic communication skills, and an ongoing role for those who do not get to regularly practise these skills.



6. Future directions for the project

This project has demonstrated the potential for a virtual patient to help improve communication skills in pharmacy students. However, there is a need to refine further the reasoning algorithm to increase the recognition of the questions, and to improve the voice and facial expressions to improve student acceptance of the patient. The significant problems encountered with various hardware and software configurations have highlighted the need for ongoing support for this software to maintain its utility, particularly given the rapid changes in technology. This will require further funding.

The software has been designed to be expandable and adaptable to a variety of settings. One use being considered is to develop a tool to encourage inter-disciplinary teaching. One such possibility is to have pharmacy and medical students 'interview' a virtual patient to take a medication history and then have them discuss the interview and propose a plan for managing the patient's medicines.



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Appendices



Appendix 1 Terms of reference for the reference committee

Computer-Generated Digital Patient Project Reference Committee Terms of Reference

Purpose:

- To support the long-term implementation/dissemination of the Computer-generated Digital Patient for Teaching in Pharmacy Practice Project

Role:

- To advise the project team to realise the Computer-generated Digital Patient for Teaching in Pharmacy Practice Project in accordance with the proposal funded by the Carrick Institute for Learning and Teaching in Higher Education
- Advocate support for the Project at the highest levels of the University, the profession, and the wider healthcare community
- Provide the Project team with guidance and support to meet its obligations
- To review the Project to determine that it is pedagogically sound
- To review the Project to ensure its acceptability and applicability to students
- Take into account the views of the Project team and other relevant groups
- To identify potential ongoing financial support for the Project beyond 2009

Composition:

The committee will comprise one representative of each of the following:

Pharmacy students - nominated from the National Association of Pharmacy Students of Australia

Pharmacy Practice academics - nominated from The University of Sydney

Heads of Pharmacy Schools - nominated from the Committee of Heads of Pharmacy Schools of Australia and New Zealand

University IT departments - identified from the University of Newcastle

Pharmacy Boards - nominated from the Australian Pharmacy Council

University Teaching and Learning departments - identified from the University of Newcastle

Information Systems academics - nominated from the University of Technology, Sydney

Pharmacy profession - nominated from the Pharmaceutical Society of Australia

Medical profession - identified from the School of Medicine and Public Health, the University of Newcastle, with an interest in medical education

Administration:

- Meet three times throughout the project
- Meetings by face-to-face and/or teleconference

Communication

- All reports from the Project team will be provided to the Reference committee prior to each meeting
- Members of the Project team may make presentations to the committee as required
- The Reference committee will provide written advice within two weeks of each committee meeting to the Project team



Appendix 2: Baseline questionnaire of students

Please complete all questions.

Please enter your Study ID (this was the number given to you at the beginning of the study and will start with either 'N', 'C' or 'M' e.g., 'M002'). _____

To make sure we have a good mix of participants we would like to start by finding out a little about you. Please answer the following questions:

Q1a. What is your age in years? _____

Q1b What is your sex?

- ☐ Male
- ☐ Female

Q1c Where were you born?

- ☐ Australia
- ☐ Overseas

Q1d Where were your parents born?

- ☐ Both in Australia
- ☐ One in Australia and one overseas
- ☐ Both overseas

Q1e What is the main language you speak at home?

- ☐ English
- ☐ Other (please state _____)

Q1f Are you enrolled as an overseas or domestic student?

- ☐ Overseas student
- ☐ Domestic student

Q1g Have you ever worked in a pharmacy?

- ☐ No
- ☐ Yes → How long have you worked in pharmacy? ____/____
(years/months)

Q2. Please indicate your familiarity with computers:

- ☐ Extremely Poor
- ☐ Below Average
- ☐ Average
- ☐ Above Average
- ☐ Excellent



- Q3. We would like to ask you some questions about how you feel about your communication skills. Please read the following statements and indicate how strongly you agree or disagree with them (please tick **ONE** box per line)

	Strongly Disagree	Disagree	No opinion	Agree	Strongly Agree
Q3A. I am confident in my ability to take a patient history	☐	☐	☐	☐	☐
Q3B. I am confident speaking with patients	☐	☐	☐	☐	☐
Q3C. I need more practice in history-taking	☐	☐	☐	☐	☐
Q3D. My general communication skills are very good	☐	☐	☐	☐	☐
Q3E. I always get all the relevant information I need from a patient	☐	☐	☐	☐	☐
Q3F. Medication histories are easy for me to obtain	☐	☐	☐	☐	☐
Q3G. I understand when to use open-ended questions	☐	☐	☐	☐	☐
Q3H. I understand when to use closed-ended questions	☐	☐	☐	☐	☐
Q3I. I find it hard to give advice on how to use a medicine	☐	☐	☐	☐	☐



Appendix 3: Additional questions asked of users

Q3. We would now like to ask you some questions about the virtual patient software that you have been using. Please read the following statements and indicate how strongly you agree or disagree with each (Please tick **ONE** box per line)

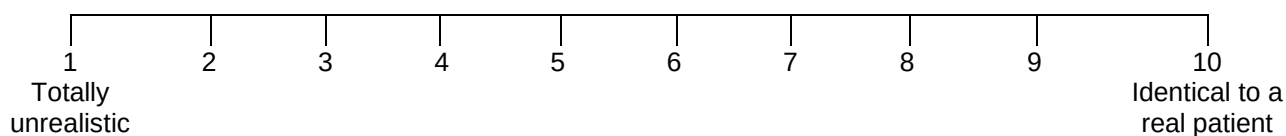
	Strongly Disagree	Disagree	No opinion	Agree	Strongly Agree
Q3A. Software instructions were easy to follow	☐	☐	☐	☐	☐
Q3B. I enjoyed using the program	☐	☐	☐	☐	☐
Q3C. The program as a whole was difficult to understand	☐	☐	☐	☐	☐
Q3D. The program was too slow to respond	☐	☐	☐	☐	☐
Q3E. I needed to learn more about computers before I could use the program	☐	☐	☐	☐	☐
Q3F. I would use the program frequently if it was available	☐	☐	☐	☐	☐
Q3G. The virtual patient improved my learning	☐	☐	☐	☐	☐
Q3H. The program helped me understand how to take a patient history	☐	☐	☐	☐	☐
Q3I. The novelty of the program made me want to learn	☐	☐	☐	☐	☐
Q3J. The program got in the way of my learning	☐	☐	☐	☐	☐
Q3K. Practicing with the virtual patient will improve my confidence with real patients	☐	☐	☐	☐	☐
Q3L. Using the virtual patient has helped me identify my strengths in taking a history from a patient	☐	☐	☐	☐	☐
Q3M. The background was distracting	☐	☐	☐	☐	☐
Q3N. The case was not at the appropriate level of difficulty for my level of training	☐	☐	☐	☐	☐
Q3O. The feedback I received was helpful in enhancing my diagnostic reasoning skills	☐	☐	☐	☐	☐
Q3P. Using the virtual patient helped me identify my weaknesses in taking a history from a patient	☐	☐	☐	☐	☐
Q3Q. After using the virtual patient I feel better prepared to care for real-life patients with these complaints	☐	☐	☐	☐	☐
Q3R. After using the virtual patient I feel better prepared to make a diagnosis in a real-life patient with these complaints	☐	☐	☐	☐	☐
Q3S. After using the virtual patient I feel better prepared to select the appropriate management for a patient with these complaints	☐	☐	☐	☐	☐
Q3T. Using the virtual patient helped me identify areas of communication that I could work on	☐	☐	☐	☐	☐
Q3U. Using the virtual patient helped me learn a systematic way of asking questions	☐	☐	☐	☐	☐



- Q4. We would now like to ask you about how realistic the virtual patient was. Please read each of the following statements and indicate how strongly you agree or disagree with each one (please tick only **ONE** box per line)?

	Strongly Disagree	Disagree	No opinion	Agree	Strongly Agree
Q4A. The virtual patient appeared authentic	☐	☐	☐	☐	☐
Q4B. The virtual patient acted like a real patient	☐	☐	☐	☐	☐
Q4C. The virtual patient appeared to withhold information	☐	☐	☐	☐	☐
Q4D. The virtual patient simulated physical complaints unrealistically	☐	☐	☐	☐	☐
Q4E. The virtual patient's appearance fitted the role	☐	☐	☐	☐	☐
Q4F. The virtual patient answered questions in a natural manner	☐	☐	☐	☐	☐
Q4G. The virtual patient did not understand my questions	☐	☐	☐	☐	☐
Q4H. The virtual patient's answers to my questions were confusing	☐	☐	☐	☐	☐
Q4I. The virtual patient's voice was difficult to understand	☐	☐	☐	☐	☐
Q4J. The virtual patient's voice had a good pitch	☐	☐	☐	☐	☐
Q4K. While using the virtual patient I felt I was making decisions as a pharmacist would make in real life	☐	☐	☐	☐	☐
Q4L. While using the virtual patient I felt I was the pharmacist looking after this patient	☐	☐	☐	☐	☐

- Q5. Finally, on the following scale overall how realistic would you rate using the Virtual Patient (please circle **ONE** number)?



Appendix 4: Focus group discussion script

Preamble:

Thank you for attending.

- Introduce yourself -

- Make a note about mobile phones (switched off) and location of toilets
- Re-assure confidentiality and anonymity
- Reiterate that the session will take about 30-45 minutes and participants can leave at any time
- Remind them that the session will be tape-recorded and that I will take brief notes and make sure everyone is OK with that.

Please ask participants to endeavour to speak one at a time

You have had the chance to use a new virtual patient and we are very interested to ascertain your views about the virtual patient experience.

Did you find that the virtual patient had an authentic feel to the interaction?

(Follow up if needed)

Did you need to become used to interacting with the patient?

Could you feel as if you were interacting with a real patient?

What was different?

Could you hear and see clearly?

How relevant did you find the program to your needs as a student learning to counsel a patient?

(Follow up if needed)

Was there a better opportunity to learn from the interaction?

Did it last longer / shorter than a genuine interaction with a person?

Was the reaction time consistent with a live person?

How would you summarise the positive aspects of the program?

How would you summarise the negative aspects?

What do you think would improve the software?



Appendix 5: OSCE assessment instrument

Study ID number _____

General Communication skills

	YES	PART	NO
Introduces themselves to the patient			
Maintains eye contact with the patient			
Sits at same level, positions body appropriately			
Uses appropriate language (non-technical)			
Uses open- and closed-ended questions appropriately			
Explains 'why' when giving instructions			
Confirms the patient understands			

History taking - content

	YES	PART	NO
Asks who is it for			
Asks for description of symptoms (frequency, consistency of the stool)			
Asks the duration of symptoms			
Asks if they have had this recently			
Asks what their normal bowel habits are like			
Asks when the diarrhoea occurs (e.g. only morning)			
Asks if they have changed their diet			
Asks if are there any other symptoms (e.g. abdominal pain, blood in stool)			
Asks if they have they tried anything to treat it			
Asks for any other medical conditions (including allergies)			
Asks what medications are they taking			
Asks whether they have been overseas recently and if so where			
Checks they are able to drink things and keep them down			

Diagnosis and management choice

	YES	PART	NO
Correctly diagnoses as mild gastroenteritis			
Recommends rest and fluid replacement (ORS)			
Does not recommend anti-diarrhoeal unless needs to work/travel/etc			

Management advice - content

	YES	PART	NO
Explains how to use the ORS			
Make up with water			
Do not use fruit juice or soft drinks			
Use the measure and only use 200 ml of water			
Keep made up solution in fridge for up to 24 hours			
Keep in the fridge to make it taste better			
Drink two-three litres per day or as much as possible			
Gives warnings about the diarrhoea			
If continues more than another 24-48 hours see a doctor			
If the diarrhoea gets worse, foul smelling or with blood and mucus → see a doctor			
If significant abdominal pains → go to a doctor			
If unable to drink and diarrhoea continues for >48 hours see a doctor			

Yes = mentioned by student

Part = partially mentioned by student

No = not mentioned by student



Assessment of domains:

(circle one)	Poor	Fair	Good	Very Good	Excellent
History taking	1	2	3	4	5
Choice of management	1	2	3	4	5
Counselling/explanation	1	2	3	4	5

Overall assessment (out of 10): /10

As a guide:

Does everything without making a mistake:	10
Does everything very well with only minor problems:	8-9
Does most things well but a few things missing:	6-7
Just competent; missed several things but no harm done:	5
Fails to diagnose, or manage condition and/or harm could be done:	≤4

Comments:

