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Design Strategy for a Scalable Virtual Pharmacy Patient

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Abstract

This paper reports on the completion of the first stage of research of a pilot study undertaken in collaboration by 3 Australian universities. The pilot involves the development of a virtual pharmacy patient (VPP) as a study of its effects on student learning when it is used as a formative assessment tool for pharmacy students in interviewing and diagnosing a patient. The design criteria that have been incorporated into the virtual patient system are described. The novelty of this system is in its ability to track and report on the style and appropriateness of student questioning of a virtual pharmacy patient. One of the main problems in this type of system is recognition of free-text student questions. An overview of the pragmatic solution to this and the systems potential as a tool to generate a lexicon for more complex question recognition is presented.

KEYWORDS

Knowledge Acquisition; Virtual Patient; Pharmacy.

INTRODUCTION

Emphasis is given in undergraduate and graduate Pharmacy programs to developing the clinical skills of communication (e.g. history taking), diagnosing and differentiating minor illnesses from those that require referral, choosing the most appropriate treatment for minor illnesses, and counselling on the correct use of the suggested treatment. As pharmacists are not able to make extensive physical examinations of patients, they are often reliant on obtaining an oral history from the patient to make a diagnosis and subsequent treatment recommendation. Fortunately over 75% of minor illnesses can usually be identified using an oral history alone. The ability of student skills required for taking an oral history, analysing it and making subsequent recommendations are usually assessed through a combination of written tests and simulated patients using Objective Structured Clinical Examinations (OSCEs).

Three Australian universities were successful in a collaborative Australian Learning and Teaching Council grant (ALTC, 2007) proposal for a pilot study to develop a virtual pharmacy patient system and to evaluate its effects on student learning when used as a

formative assessment tool when compared to the use of a simulated physical patient in an OSCE. The shortcomings of using simulated actors and the efficiencies of replacing them with computer simulations will be described in more detail later in the paper. The collaboration was between The University of Newcastle, Charles Sturt University, and Monash University. These represent a broad cross-section of the current range of pharmacy programs available at Australian schools as they include major metropolitan (Melbourne), regional (Newcastle) and Rural (Wagga Wagga, Bathurst and Orange) areas, and cover both undergraduate (Melbourne, Wagga Wagga and Orange) and post-graduate (Newcastle) pharmacy programs.

This paper will describe the results of the first stage of this research – the development of a virtual pharmacy patient. The subsequent evaluation stage is scheduled to occur early in 2010. The paper will first outline a brief overview of simulated patients and virtual patient systems. It will then outline the development of the Virtual Pharmacy Patient (VPP) system resulting from the ALTC research and describe the rationale and design criteria that make this system unique. A detailed description of the system, from both an administrative teacher's perspective and from a student assessment perspective will follow. Finally, a discussion of the conclusions and future research opportunities will be presented.

VIRTUAL PATIENTS

The literature supports the educational advantages of actors being employed as simulated patients on both tutorial practice sessions and for assessments such as oral examinations, with significant improvements being seen in student's social and history-taking skills (Tamblyn et al, 2007; Wind et al, 2004). This is true even if there is no direct perception of the simulated patient as being human, that is, when the patient becomes "virtual". An early pharmacy assessment system (Fuhrman et al, 2001) used a computer interface to provide patient data and then store student answers. Faculty staff assessed the answers to these on a continuing basis and students reported that the system provided a positive learning experience that would be beneficial to their future careers, Orr (2007) reported significant increases in the their students' "...*knowledge, problem-solving, communication, and professional skills*" when Faculty members took on a role-playing positions as "virtual" patients who only communicated with students via e-mail.

Computerised simulation of patients in medicine, dentistry, pharmacy, or nursing personalise the patient by employing images of a patient 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 to assist the generation of case studies that will be presented by a computer to a student for the student's diagnosis and which will then provide feedback to the student. An early automated virtual patient system, developed for pharmacy student assessment at Monash University (Marriot, 2007), is based on a very prescriptive framework with an interface that domain teachers use to easily generate many case studies for assessment. It has 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. It allows individualised assessment scenarios to be generated for students, thus minimising plagiarism, and it can report results for large numbers of students over a reasonable range of criteria. Although it has an interactive student interface this is fairly static in nature, with student interaction limited to reading pre-set case study

notes and then choosing from a list of options for diagnosis and suggested medication and treatment. The preset case history does not allow any dynamic interaction in terms of a student's ability to investigate and explore possibilities.

The Web-SP (Zary et al, 2006) virtual patient system employed static pictures of patients. It had a similar design aim to the Monash University described above, to develop a framework that allowed the scalable generation of new medical scenarios in domains such as medicine, pharmacy and dentistry. Its advantage was that its interface permitted questioning by a student and thus opened a more dynamic engagement of the student with the virtual patient. Its restrictions, such as allowing only pre-formulated questions and providing a generic framework for domain teachers to use to generate the content of the questions, allowed it to be efficient for the development of new patient condition scenarios and put that development in the hands of the domain teachers as administrators of the system content.

Other systems have encouraged student interaction by providing video clips as responses to students questions (Bergin and 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 word content provided by static image virtual patient systems. However a drawback of using video clips of real people is that they have to be filmed initially and this takes a large amount of time to provide appropriate video sequences for every possible answer. It is also difficult to change features such as age, race, and gender, easily without involving a complete remake of the video.

Dynamic interaction is also achieved using virtual reality avatars, which are computer generated animations used as representations of patients (Cavazza and Simo, 2003). These typically do not have detailed human features but they allow easy modification of the virtual patient appearance, involving characteristics such as race, gender and age, and they can also allow physical gestures and limited expressiveness indicating emotional states to be incorporated into the virtual patient.

One of the best examples of an avatar based virtual patient operating within a virtual reality world is the Digital ANimated Avatar (DIANA), created by the University of Florida. DIANA is a female virtual character who plays the role of a patient with appendicitis, while virtual interactive character (VIC), a male virtual character, plays the role of an observing expert (Lok et al, 2006). The DIANA virtual patient is a life-size avatar that is projected onto a wall. Students interact with the avatar using voice recognition technology.

A similar system has been developed in conjunction with the Pharmacy program at Keele University in the United Kingdom (Keele University, 2009; PJ Online, 2008), which is now building 4 avatars for Monash University as part of its ePharm program (ePharm, 2009). Although no published information exists for the Keele project, it was demonstrated recently at the Monash Pharmacy Practice Symposium in Prato, Italy. The headset worn by the student for speech recognition has the potential to monitor some characteristics of the student, such as head movement. This has the potential to track non-vocal assessment items that are important in inter-personal communication and patient questioning, such as the eye contact of the student 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 models:

- students felt the avatar needed more 'emotion' and needed to be more 'expressive' (Lok, 2006) ;

- only 60% of student questions were recognised by the virtual patient (Stevens, 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 sic) and made them cognizant of the product rather than the process” (Lok, 2006).

This current state of multi-speaker, wide vocabulary and free-text interpretation is still not perfected. The speech technical difficulty with accurate and consistent speech recognition may detract from the student’s learning experience, 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 technology illustrated above, there are many advantages in using computerised virtual patients rather than actors. These include savings in the cost and time of training, and in 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 utilised for many assessments occurring simultaneously at many different locations. They can also easily record student performance and generate reports on individual student, or on aggregated class, results for both summative and formative assessments.

VIRTUAL PHARMACY PATIENT ASSESSMENT

The pilot implementation of the VPP system will initially be used for formative assessment of pharmacy students at the 3 collaborating universities. For the pilot study, students will be assessed on their oral-history skills in their coverage and style of investigative questions to diagnose three clinical scenarios: a cough, Gastro-oesophageal reflux disease (GORD), and constipation, each with 3 levels of severity: mild, moderate and severe (a total of 9 assessments for each student). Students will be randomly assigned a condition with a random severity to assess. The system will present a student with all 3 conditions at randomly selected severities before re-assessing the same conditions at different levels of severity.

Future implementations will expand the pilot range of conditions. For example, Monash University has over 250 pre-existing standardised patients, and approximately 100 clinical scenarios, that can be used. The system will also be capable of being used for summative assessment after the pilot study.

The VPP captures and records student questions to the virtual patient and the answers provided by the virtual patient to the student. This allows individual student’s assessments to be later interrogated by a teacher to examine the chronology of a student’s reasoning and progress in fine detail (if required). The system provides formative feedback to students. A complete feedback summary is also able to be presented to a student at the end of each of their assessments (after an assessment of a specific condition-severity pair). If this was 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.

DESIGN PHILOSOPHY AND IMPLEMENTATION

The use of an expressive face was adopted by the VPP and the virtual patient image was created as a realistic 3-dimensional head with fine detail that is capable of showing expressions and vocalising text so that it “talks” to the student. The face and voice module are being constructed at Charles Sturt University. The reasoning and assessment modules were constructed at The University of Newcastle.

For the pilot study a server-based architecture was adopted. 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 VPP program was written in Java (using NetBeans IDE) and some data required by the reasoning logic was ported to the client to speed up processing.

Student Assessment

When a student logs in to the VPP to do an assessment (Figure 1), the assessment module looks at their 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. Effectively a student asks the virtual patient free-form questions (typed free-text questions that have no restrictions as to their content) 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 (smile etc) to the face module to vocalise and display.

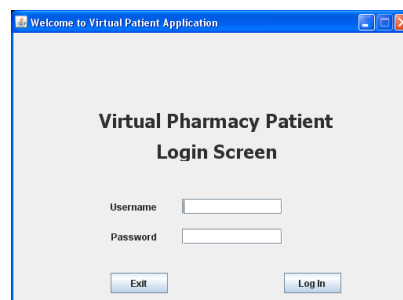


Figure 1- VPP Login Screen

Some virtual patient systems, such as Web-SP (Zary et al, 2006), avoided the problems of interpreting student’s free-form questions by restricting the allowed questions so that they had to be chosen by the student 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” (ibid).

Adoption of a free-text style of student questioning was one of the earliest design decisions for the VPP. As indicated earlier this represents one of the main problem areas in current virtual patient systems. Systems that use 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 a reasonably low accuracy as the rate of incorrectly interpreted student questions rises. This is compounded if speech recognition technology is used instead of text entry.

The VPP system is capable of having a speech recognition module added at a later stage however, for the pilot study, a policy of only accepting student questions as text was adopted to avoid the interpretation problems caused by speech recognition and to facilitate the logistics of the practical assessment of many students within a common laboratory setting, where the use of headphones allows private communication from the computer to the student but there is no interference between individual student assessments (as would be the case if speech recognition using microphones was employed). To further reduce errors caused by incorrectly spelt words, a spell-checker/corrector module was incorporated into the virtual patient student interface to analyse and corrects student questions as they enter their text. The student question is tokenised into individual words after it has been input into the VPP, and then punctuation and irrelevant words are removed. The student question is stored in complete form also by the VPP for reporting the chronological sequence of student question – virtual patient answer, but the VPP logic operates on the tokenised form of the student question.

The conditions that needed 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 and should be questioned across many conditions, including such areas as *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 condition and *Frequency of Cough* for the cough condition. Categories were populated with questions that were expected to be asked by a student to ensure they had investigated that category.

Although the pilot only required that one question in the category be asked by a student to indicate coverage of that category, the VPP system is capable of finer reporting detail and so the design further divided the categories, with their associated expected questions, into specific *sub-categories*, for example the category *Duration* (of condition) was sub-divided into *Start of condition*, *Duration* (interval) of condition and *Existence* of condition. This enables finer reporting in the future and also caters for the analysis logic necessary to determine appropriate sequencing and style of questions that are asked by students. In some cases the sub-categories were chosen based on grouping the open-ended and closed-ended expected 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*, *Symptoms-Aches*, *Other Symptoms-Fever*, and so on, for the cough condition.

The pilot study concerns itself with the assessment of a student's 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 were necessary to be asked to investigate specific categories associated with the clinical condition. Once the student's question had been recognised and associated with one of the expected questions, a suitable answer can be easily supplied to the student by the virtual patient. If the VPP does not understand the student question (it could not be matched against any of the expected questions) then the virtual patient responds that it did not understand the question and requests that the student re-phrase it.

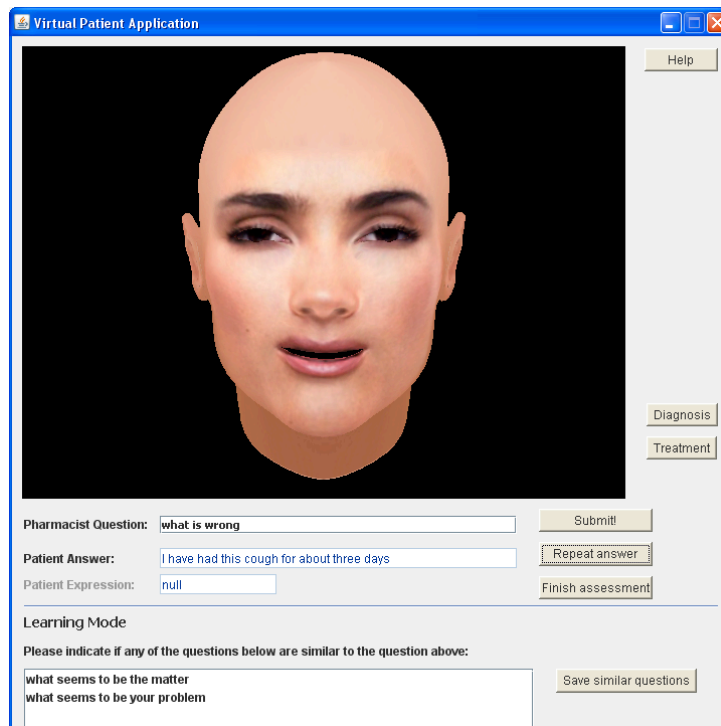


Figure 2 - VPP Student Question with Learning Mode

Matching of the tokenised student question is 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 are termed *Target Questions* and the variation phrases are termed *Alias Questions*. For a specific domain, there can be many aliases associated with a particular target question however each target question is matched against only one Category/sub-category combination.

The VPP student assessment interface has a learning module (Figure 2) that can be incorporated into it when the system is being used in a training mode by a student (rather than in assessment mode), or that can be omitted if the student is undergoing an actual assessment. 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 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, 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 that the recognised student question “What is wrong” maps to. Note that in Figure 2 textboxes for the virtual patient answer and expression are shown but these will be hidden during a real assessment.

A VPP design decision was adopted that only investigative questions would be allowed as student question input, thus avoiding potential problems when trying to interpret a suggestion or treatment advice as a question, such as when a pharmacist might suggest to a patient that

he/she take a medication as opposed to when they are asking the patient whether they are taking a specific medication. Students are directed, in the initial assessment interface screens, not to suggest treatments or to offer explanations or indicate diagnoses as part of their questioning. 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, and throughout, the assessment.

Student Feedback

During a student's assessment session, feedback is provided in response to specific student questions. For example, indications to students that they 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, then the virtual patient will issue a response indicating that they are offended by the student's language. Unsolicited responses from the virtual patient also provide feedback clues to the student, such as indications that issued at appropriately timed intervals after the assessment has started indicating that they need to finish the interview, using statements such as "Will this take long, I need to catch a bus in 5 minutes". Emotions can be associated with these types of feedback in the virtual patient face, where the virtual patient might frown or appear visually frustrated.

Domain	Example Questions
Anything make it worse/better	Is it better in the morning
Description of cough	Describe the cough
Disturbing activities	Does it affect your day

Figure 3 - Summary Form displayed for Student Feedback

The VPP provides feedback to the student on their coverage of the *scope* of questions required 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, as well being 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 3).

The VPP is novel from 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 will be given to the student on whether they:

- repeated questions for which the virtual patient had already supplied answers;
- asked too many close-ended 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 close-ended question. For example, if a student initially asks a close ended 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 breast feeding?” 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).

For reasons described earlier, the VPP records the student’s diagnosis of the condition and also their recommendations for treatment using separate forms to the assessment questioning interface form (launched from the buttons shown in Figure 2). The student diagnosis and treatments can be developed, with content able to be added and modified at any time throughout the assessment. At the end of the assessment the student is provided 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). Students can print out the feedback provided by the VPP 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 (Marriot, 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 (VPP) system.

Although the domain scenarios (conditions) that will be used for the pilot assessment implementation of the current VPP system are limited to 3 conditions and to conditions that need to be diagnosed by pharmacists, the VPP system itself is scalable to other 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 VPP system can be expanded by both domain teachers and also by students when it is used for formative training. This gives the VPP the potential to be used in most health disciplines where structure questioning is important.

Teachers log into the VPP system as administrators and are responsible for the content of the clinical domains that are to be assessed. They can easily modify existing domains, categories and subcategories, and they can add new ones (Figure 4). 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.

As indicated earlier in the student assessment section, 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 5). This ability to expand the system lexicon enables the system to “learn” and become more efficient in future assessments due to its increased student question recognition capability. Once alias questions are stored in the VPP 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 VPP as it enables a quick population of the recognition knowledge for new conditions.

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 close ended questions, or whether it should be questioned starting with a closed (or an 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. For example, the example given earlier of asking whether a (female) patient is pregnant given that a student has already asked if the patient was breast-feeding.

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 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 the 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.

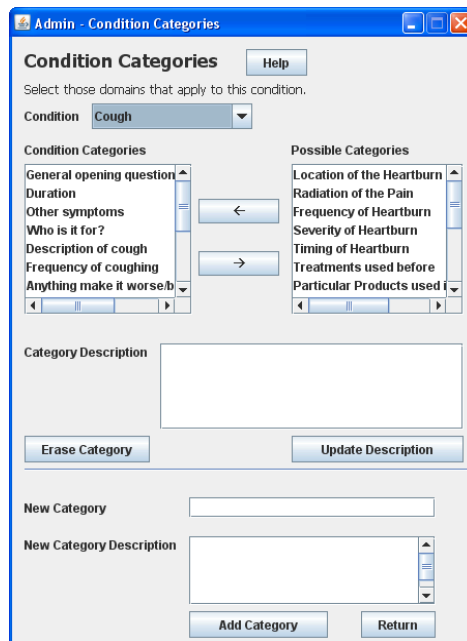


Figure 4 - VPP Teacher Category Management

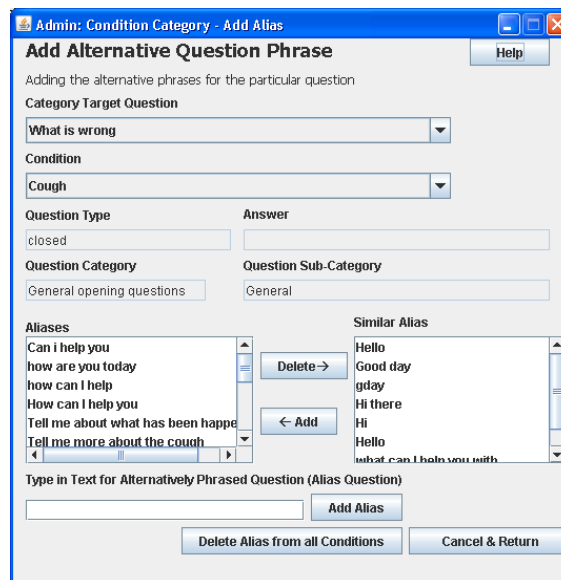


Figure 5 - VPP Teacher Management of Aliases for Target Questions

Teacher Feedback

The VPP provides reports to teachers relating to individual student performance over specific assessment, of individual student performance 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 get 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 6.

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

Figure 6 - Aggregated Report for Specified Condition

The VPP provides a printable report to teachers of all the student questions that were unrecognised by the virtual patient during assessments. This allows a teacher to review the questions and then, if required, to easily add them to the lexicon of aliases. It also provides the teacher with a checking capacity in that an unrecognised student question may identify a potential new Target question (and hence a new sub-category or even category/sub-category combination).

DISCUSSION AND FUTURE RESEARCH

Problems in the initial development were that there was no training data available to employ more sophisticated student question matching techniques (such as a neural nets) and that there was no predefined or predictable sequence to the student questioning. This dictated the use of a simple data-matching technique and so the prototype's effectiveness depends on the extent of the lexicon it uses to match a student question. A design decision was to advise that the system will only respond to single-purpose questions, as multiple questions would require sophisticated lexical analysis techniques to determine that there was more than one question to be matched. 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 is easily achievable due to the generality of domain and scalability incorporated in its design.

The initial development of the VPP has been achieved. A trial of 6 pharmacy graduates were used to populate alias questions and to trial the teacher assessment interface. They also had a quick look at the student assessment interface. As a result of this exercise the alias possibilities increased by 300% and some additional categories were suggested. They expressed interest in the student assessment and were satisfied with the administration and management teacher interface.

Population of the alias questions and additional categories/ sub-categories will continue using an extensive deployment of a web-based questionnaire that will be sent to pharmacists and past students to obtain a large number of versions of aliases for target questions in an electronic format. These will be imported into the VPP database and then used to generate a large lexicon for the three conditions being used for of the pilot.

This illustrates one of the future uses for the VPP achieved by its adoption of scalability as a design goal. Once a large lexicon of aliases is established for a particular condition, the re-use

of the aliases is easily done through the management interfaces. The VPP allows a large lexicon to be developed quickly and this can then be used as a training set in future implementations that may employ more sophisticated lexical analysis, neural nets, or semantic taxonomies, to categorise student questions into expected target questions.

Although Deladisma et al (2008) reported that the race of virtual patients, such as DIANA, had no significant differences on student's satisfaction with them as learning tools, facial expression clues, and identification factors of age, gender and race, can affect individual student perceptions of a patient and the severity of their condition (Hirsh et al, 2008) and so the provision of a greater variety of realistic faces with cues to gender, age and race will greatly enhance the student's ability to interpret and analyse problems.

For the pilot, inter-category assessment reasoning logic only specifies a list of possible appropriate follow-up questions, from which any are allowable. If any one of them is subsequently asked by the student, then nothing is reported in terms of the student not asking the other questions. Also, the reasoning needed to indicate deeper intra-category sequencing order, or to indicate "appropriate" following intra-category questions, was left for later implementation due to the additional complexity involved in determining "particular" following questions from a set of possible allowed following questions. This could have been solved using subsets of required intra-category target questions however, the extra complexity was not thought to be justified at this point as the pilot only required an indication that a question from a category was asked for the assessment, and the present intra-category logic will provide feedback that inappropriate questions have been asked.

CONCLUSIONS

This paper has outlined the novel nature of the VPP in its ability to assess the *style* of student questioning as well as the context of the questions. It has described how this is easily accomplished by domain teacher in their role as administrators.

The rationale for the design approach adopted to develop a virtual pharmacy patient has been described and illustrated through domain examples. The paper illustrated the pragmatic design approach adopted by the VPP to deal with the free-text student question recognition problem. Whilst the student assessment stage of the research, which includes a performance evaluation of the VPP and its usefulness as an assessment tool, still has to be carried out next year, the present tool's pragmatic approach has been seen to be useful as a means of easily generating training data for systems that employ more complex recognition analysis.

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