Virtual Humans Playing the Role of Patients in Self-medication Consultations: Perspectives of Undergraduate Pharmacy Students

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Abstract: This paper describes an interactive application conceived to improve non-prescription medicines consultation skills in undergraduate Pharmacy students and a user test carried out with two sets of participants. Resorting to virtual humans that play the role of patients and communicate with the students by speech and by facial and body language, the application stimulates students' engagement in true-to-life situations in a controllable environment. Two usage modes are available: the training mode, used autonomously by the student, and the assessment mode which is used by the teacher to evaluate the student's performance. A BackOffice Web application was also implemented to assist teachers' work. It supports the collection of data about students' performance, the creation of new self-medication situations and their posterior insertion in the application. The overall opinion of the participants in the user-study was quite positive about the usefulness of the application as a tool to improve students' non-prescription medicines consultation skills. Moreover, some valuable suggestions were gathered during this testing process.

SCIENCE AND TECHNOLOGY PUBLICATIONS

1 INTRODUCTION

Self-medication is common in community pharmacy. For example, research indicates that about a quarter of the clients in urban Portuguese pharmacies purchased medicines without physicians' advice (Martins et al., 2002). It is acknowledged that self-medication has a number of potential advantages for stakeholders - consumers, health professionals, pharmaceutical industry and the health system - but it is not without risks, namely adverse effects (Asseray et al., 2013) (Schmiedl et al., 2014) and misuse (Cooper, 2013). International and national organizations, such as the World Health Organisation, have advocated a role for community pharmacists in assisting consumers who present minor ailments or request non-prescription medicines.

In his seminal work on quality of care Donabedian considered both technical and interpersonal elements in the performance of practitioners (Donabedian, 1988). The latter was regarded as "the vehicle by which technical care is implemented and on which its success depends". In other words, a successful consultation relies not only in clinical knowledge and judgment but also on communication; self-medication consultations are no exception. Therefore pharmacy educators are faced with the challenge of developing both clinical and communication skills in students.

This paper describes an interactive application to support skills training and assessment of undergraduate Pharmaceutical Sciences students and continues previous works from the same team (Cláudio et al., 2015a). Although training and assessing professional competence is a multidimensional reality, which involves trainees' work beyond passing or failing exams, but collecting evidence of competence (i.e. the use of skills according to standards of qualification) (Epstein and Hundert, 2002), simulation is increasingly being used for competencies based training and assessment. This is a result of changes in health care delivery and academic environments (e.g. the safety culture and limited patient availability, respectively), and the

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shift to outcomes-based education, being clear the advantages of simulation to demonstrate the acquisition of basic competences (Scalese et al., 2008). The present prototype simulates realistic self-medication consultations using Virtual Humans (VH), with the purpose of improving students' clinical and communication skills in self-medication. The prototype was developed with the aid of Unity3D, a software tool for videogames. Both Portuguese and English versions are available.

Firstly, users must select a self-medication scenario and then, one VH must be chosen from four characters (both genders and two different age groups). The VH is depicted in a community pharmacy environment and has natural body movements, obtained by motion capture. Users, playing the role of a pharmacist, communicate with the VH by choosing textual options in the application interface. Options are scored according to their level of correctness at each point of the non-prescription medicine consultation process; the goal is to obtain the highest score by selecting the options that are more correct.

The VH communicates verbally, by a synthetic voice synchronised with the movements of the lips, and non-verbally, by emulating facial and body expressions as a response to the options chosen by the user.

When the consultation is completed, users receive feedback on their overall score and on their test score in different consultation stages (e.g. patient assessment and counselling). The application saves the tests scores for each user, enabling data analysis and progress monitoring over time.

A preliminary evaluation of the prototype was conducted with seven experts (academic and practitioners), from different organisations (Cláudio et al., 2015a). This paper describes a user-study involving two sets of students.

The paper is organized as follows: next section presents the most relevant work in the area; sections III to V describe our application; section VI reports the evaluation; and section VII presents conclusions and future work.

2 STATE OF THE ART

Healthcare education has used VH as a useful resource (Cláudio et al., 2015b; Hoffman, 2000), although its application in pharmacy education seems scarce. Thus, one first step in ascertaining pedagogical usefulness would be exploring the advantages provided by VH in the development of pharmacists' clinical and communication skills.

A systematic review with meta-analysis on the use of computer-based VH solutions for health professions, evaluated the outcome of this educational resource on users' satisfaction, knowledge, attitudes and communication/clinical skills (Cook et al., 2010). Total of 3,285 learners (2,115 medical students, 272 nursing students, both professionals and other learners) allowed concluding that VH were associated with large positive effects compared with no intervention. However, VH effect compared with non-computer instruction was on average smaller, and not always statistically significant, suggesting lower effectiveness on a wider sample of healthcare learners. The large inconsistency among study results led the authors to exert caution when drawing conclusions about true effectiveness differences between methods.

Cook and colleagues reported also results from four qualitative studies with medical students, which returned interesting accounts on learners' views concerning the use of VH (Cook et al., 2010). These were perceived to bring advantages over other educational methods, especially in what concerns convenience of access, a relaxing learning environment, and case evolution according to learners' actions and feedback. Actually, these were key determinants of participants' satisfaction and engagement. Case realism was associated both with the VH presentation and case material, including the type of case presented. Additional topics contributing to improve learning outcomes comprised repetition until demonstration of proficiency, enhanced feedback, and explicitly contrasting cases (Cook et al., 2010).

A more recent review by Jabbur-Lopes and colleagues focused on the use of VH in pharmaceutical care education to pharmacy students (Jabbur-Lopes et al., 2012). Using less stringent criteria than the work of Cook et al., this review found seven articles, four of which were conducted in North America. The authors conclude that the paucity of published studies involving VH suggests an under use of this tool in pharmacy education and this conclusion is supported by a cross-sectional survey in a convenience sample of 194 European pharmacy undergraduates (Cavaco and Madeira, 2012), where only 12 students, from six universities in six different countries reported experiences with VH. Those were satisfied with this educational method and non-users revealed themselves in favour of the potential benefits of VH in pharmacy education.

Computerised approaches make use of video clips to create tools for skills training, while others fall back on non-computerised virtual patients. One example of the last comes from teaching self-care consultation skills to pharmacy students in North America (Orr, 2007); this study found an improvement in overall knowledge and communication skills. An example of the former i.e. a VH application based on video images, photographs of people in full size and realistic background sounds, received the name of Virtual Practice Environment (VPE) (Hussainy et al., 2012). This solution tries to create a 3D immersive environment for high fidelity patient care training in community pharmacies. Furthermore, background images can also be combined with previous recordings of staged situations. Another example of high-end proposals is the Interactive Simulated Patient (Bergin and Fors, 2003). This multimedia application was developed for healthcare students, to explore and solve clinical cases, aiming to help students' practice of their clinical reasoning skills. This is a sophisticated resource where the interaction with the virtual patient is made through natural language, with text input in a dialog box, and the patient's answers being offered through video clips.

The AVATALK is a device that uses VH for skills training in different areas (Hubal et al., 2000). The main features comprise emotions expression with, the possibility of behaviour modelling, using natural language processing techniques. As with previous proposals there is an option of integration of three-dimensional scenarios. It was tested in medical practice training together with another application, the Trauma Patient Simulator, which defines scenarios, medical histories, and the rules of simulation between the patient and the trainee. The learning results from the two last applications evaluation were quite encouraging.

Compared to these solutions, our application has additional features: it can be used both in training and assessment mode; it includes a BackOffice application to support teachers' work, in particular it offers an easy-to-use process for definition of new self-medication cases that requires no informatics skills from the user; and the application uses the overall information contained in these definitions to automate a set of choices concerning the VH that populate the simulation. Next sessions gives details about these features.

3 DESCRIPTION OF THE APPLICATION

Virtual Pharmacy was designed to be used by Pharmaceutical Sciences students in two usage contexts: training and assessment. In both cases, the student selects, from a list, a self-medication situation. After that, he chooses a VH among a set of four possibilities (both genres, young and old characters).

The application recreates the chosen situation of self-medication which takes place in a virtual community pharmacy, represented as a background image that is randomly selected from a set of images. The VH plays the role of a patient suffering from that particular clinical condition and requiring the assistance of a healthcare professional (Figure 1). The VH communicates verbally by a synthetic voice synchronised with the lips.

Along with verbal communication, the VH also communicates through body animations and by changing his facial expressions (neutral, satisfied and discontent). The initial expression is random and may change in the course of the interaction, as a response to the right or wrong choices made by the student (Figure 2). The student, playing the role of a pharmacist behind the counter, interacts with the VH by selecting one of three textual options displayed in the application interface (right side of Figure 1). Each set of three options includes questions with different levels of correctness to which are assigned different scores. The course of the simulation is guided by the options sequentially chosen by the student.

After performing a sequence of interactions with the VH, the student completes the virtual consultation and receives feedback on his overall scores.

When in training mode, the student uses the application autonomously and, by the end of each virtual consultation, together with his overall scores, he receives detailed information about the correctness of his previous choices and about his progress along successive training sessions. The application also provides links to educational contents related to the topics of the self-medication situations presented.

In assessment mode, the application displays the student's overall scores and stores results in a database for posterior analysis by the teacher with the purpose of assigning him a mark.

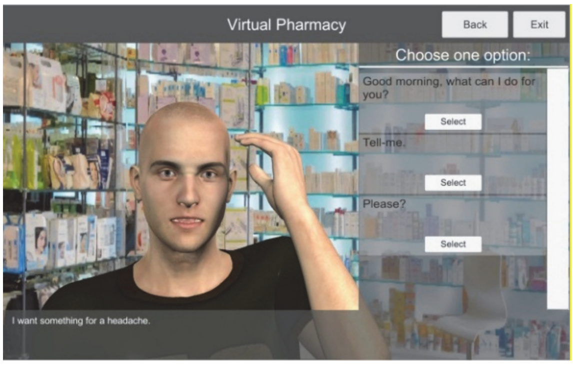

Figure 1: Application interface- the animated virtual patient describing his problem (a headache) using speech and gesture; below this, the subtitles of the speech that accompanies the speech sound; on the right side, the three options presented for the user to choose one.

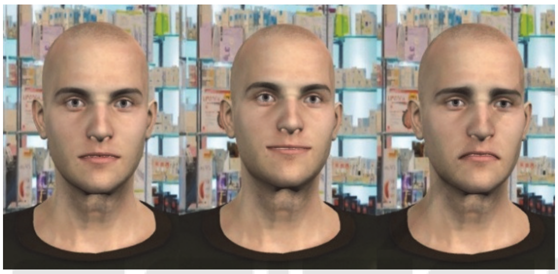

Figure 2: Virtual Patient exhibiting three distinct facial expressions (from left to right): neutral, satisfied and discontent.

3.1 Architecture of the Application

The Virtual Pharmacy application was developed for PC. It has three main components: the VP_SIM, the VP_Office and the Speech Generator. Each one of these components contains several modules.

The VP_SIM is the core component that is intended to be used by the students. It is implemented in C#, using Unity3D, and comprises the User Interface and the Application Controller that commands the simulation of the situations.

The VP_Office implements the BackOffice Application (BOA) that supports teachers' tasks. Its main component is the Dialogue Creator, implemented using a javascript libray, JointJS (jointjs.com), to build graphs. The Dialogue Creator offers a graphical interactive interface to define or edit self-medication situations, described as a graph. Each node in the graph corresponds to a phrase that is articulated by the VH or to an option and its associated score. The nodes representing the speech of the patient are connected to several nodes which are the options to be shown to the student. In contrast, the nodes that correspond to an option presented to the student have only one link to a phrase of the patient; this node corresponds to the reaction of the virtual patient to the choice made by the student. Using the graph to build the dialogues does not require informatics skills.

The BOA application provides also other functionalities for the teachers: an interface to upload complementary elements of study to be shown in the training mode of VP_SIM; and an interface to monitor students' progress over time. A MySQL database is used to store the information which is shared by the VP_SIM and the VP_Office.

When the VP_SIM application is launched, the Data Controller module reads from the database the information necessary to create the list of situations to be displayed in the interface and to manage the course of the simulations. Detailed information can be obtained in (Cláudio et al., 2015a).

The third component, Speech Generator is responsible for the VH correct articulation of the speech as explained in the following section.

3.2 Animations and Speech

The four VH's models in the application represent adults of both genders and two different age groups: young and old. They were obtained from DazStudio (daz3d.com) and enriched with body and facial animations using two different animation techniques: skeletal animation for the body and morph target animation for the face. Both facial and body animations were combined in Blender (blender.org) and then exported to Unity3D.

Facial animations comprise the expression of emotions and the movement of the lips synchronized with speech. Body animations were built based on motion capture data downloaded from the Unity3D assets store.

To attain a good level of realism, the synchronization of the lips with the sound is an essential feature in speech animation, because observers are very sensitive to small errors (Xu, 2013). The component of the application that processes speech generation is the Speech Generator which relies on a Microsoft speech library (www.microsoft.com/en-us/download/details.aspx ?id=10121) to convert text to speech. Taking into account the age and gender of the character, for each phrase of the dialogue two files are created: an audio file, in wav format, with the speech of the character, and an XML file, with the respective animation.

Body animations of the VH are triggered by keywords in the dialogue that are connected to the self- medication situation. For instance, the character brings his hand to the head while he articulates a sentence describing the symptoms for headache. The module Character Behavior Controller is responsible for analysing the speech lines of the VH in the graph to detect the keywords connected with animations. This module also controls the facial animation of the VH, reacting to the student's performance while using the tool.

4 EVALUATION

A preliminary version of VP_SIM was evaluated with 7 experts on pharmacy practice, to study the usability and suitability of the application. The results of this user-study revealed that these professionals considered VP_SIM a valuable tool for training and assessing students' OTC (over-the-counter, i.e., drugs that do not require a doctor's prescription) counselling skills (Cláudio et al., 2015a). But some associated dangers were identified: normal limitations related to a predefined dialogue that does not cover all possible patient reactions and events in a real situation. In their opinion, the contact with the simulated situations in the application should preferably be followed by real interactions in a true community pharmacy.

The majority of panel experts were not supportive of replacing the face-to-face teaching or the internship, since there are behavioural competencies that need real interactions and experience. In their opinion, the application as a starting point should be kept in a mix training environment. The subsequent version of VP_SIM was fine-tuned and evaluated with students.

4.1 Participants and Procedure

The evaluation resorted to two distinct sets of volunteer Pharmaceutical Sciences students. A first set comprised 10 undergraduate Pharmaceutical Sciences students in their 4th year of studies; a second set was composed by 42 students in the last year of their Pharmaceutical Sciences course, performing their curricular internship behind a counter in a community pharmacy. Students in both sets were from the same university to ensure identical learning backgrounds. Each student tried the application, performing the same list of suggested tasks and afterwards answered to a set of questions in a Google Forms questionnaire.

The list of suggested tasks included: i) to start the application and make the registration and login steps; ii) to solve the Headache situation choosing the younger male character; iii) to solve the Cough situation with a character of their own choice among the available 4 in the interface; iv) and finally, to consult the summarized information about his/her performance in the resolution of the situations.

Besides the biographical questions to obtain a general profile of the user, three groups of questions were asked: i) specific questions about the interface of the application and the VH, and some questions to gather an overall evaluation; ii) a SUS (System Usability Scale) questionnaire (Brooke,1996); and iii) questions to infer about application's suitability and potential use for students' training and assessment in the area of Pharmaceutical Sciences.

The majority of the questions in groups 1 and 2 were answered using a Likert scale (from 1- strongly disagree to 5- strongly agree). All questions in group 3 were open-ended questions. Both set of users answered to the 3 groups of questions in a Google Forms questionnaire.

The user-study started with the 10 students (5 women, 5 men) in the 4th year. They made the tests in a classroom in their own faculty, just after a class, and all of them used the same computer with the following characteristics: CPU- Intel Core i7, 2,4 GHz; RAM: 8GB; GPU: Nvidia GeForce GT 650M, 1GB.

The interviewer, observing the students while they were performing the suggested tasks, was able to perceive the difficulties the participants were experiencing with the interface and registered all their verbal comments. This feedback collected by the interviewer was used to eliminate some ambiguities in the interface of the application before the evaluation with the internship students. The 42 internship students (35 women, 7 men) received an email explaining how to download and execute the application in their own computer, the list of suggested tasks and the link to the Google Forms questionnaire to fulfil afterwards.

Students of the 4th year, still with no contact experience with real patients, used the training version of VP_SIM and internship students used the assessment version. As mentioned before, the latter displays only the overall scores of the student, while the training version provides detailed information about the correctness of the previous choices, on the progress over successive sessions of training and links to educational content.

Table 1: Median values of the answers to questions about the interface (group 1).

	Questions about the interface (answered with a Likert scale: from *1- strongly disagree* to *5- strongly agree*)	4th year students' (median)	Internship students' (median)
1	The information is properly displayed on the screen (e.g. number and locations of buttons/options)	4	4
2	Performing tasks is straightforward, i.e., the choice of options and/or menus is easy	4	4
3	The operation speed of the application is adequate	5	4
4	The choice of self-medication situations is clear	4	4
5	The choice of self-medication situations is straightforward, i.e., it does not require too many steps	4	4
6	The choices given to the user are meaningful	4.5	4

Table 2: Median values of the answers to questions about the Virtual Humans (group 1).

	Questions about the Virtual Humans (answered with a Likert scale: from *1- strongly disagree* to *5- strongly agree*)	4th year students' (median)	Internship students' (median)
1	The selection of the virtual human is clear	5	4
2	The selection of the virtual human is straightforward, i.e., it does not require too many steps	5	4
3	The virtual humans are very realistic	4	3
4	The cloths of the virtual humans are very realistic	3.5	3
5	The way the virtual humans look is very realistic	4	3
6	The movements of the virtual humans' bodies are very realistic	3	3
7	It is easy to hear / understand the sentences articulated by the virtual humans	4	4
8	The movements of the virtual humans' lips are synchronized with the voice	4	3
9	The feedback provided by the virtual humans' facial expressions is useful for the user of the application	4	4

Table 3: Median values of the answers to questions about the overall opinion of the application (group 1).

	Questions about the overall opinion of the application (answered with a Likert scale: from *1- strongly disagree* to *5- strongly agree*)	4th year students' (median)	Internship students' (median)
1	I am content with the information the application gives me about my performance in the resolution of the cases	5	4
2	I am content with the summarized information the application gives me about my performance in the resolution of all the previous cases	5	4
3	The application is easy to use	5	4
4	The application responds to my anticipated goals	5	4

4.2 Results and Discussion

The results (median of users' scores) of the questions in group 1 are presented in table 1 (interface), table 2 (VH) and table 3 (general opinion). The overall results are quite positive; lower scores appear in table 2 and are related to the realistic appearance and behavior of the VH playing the role of patients. Higher quality models, eventually commercial, would most probably produce better user scores, concerning the questions in lines 3, 4 and 5; body movements can also be improved resorting, for instance, to better motion capture data. The non-controllable issue is in line 8, because a natural speech articulation requires a very good synchronization between lips' animation and sound, a demanding requirement in terms of hardware. It should be noticed that internships used their own computers, so we do not have control on the quality of the hardware.

We could have asked those participants about the hardware they were using. But we considered this question counter-productive because i) that can be a hard question to answer by someone potentially without informatics skills, and ii) that question would, most likely, prevent them from participating.

That is, a "less-good" computer may have produced a lower impression on the user. This speculation should be proved in future evaluations, probably using always the same (type of) computer, like 4th year students did. However, we have to be cautious because this requirement of using the same type of computer may hinder user testing.

Regarding the feedback provided by the virtual humans' facial expressions, reflecting his/her performance (Table 2, line 9), students in the two sets agreed that it is useful (scores' median = 4). Half of the participants mentioned that more expressions were needed, such as surprised, feeling pain, doubtful, confused, concerned and angry.

Students in the 4th year scored with 5 the questions in table 3 (general opinion), while internships scored only with 4. Notice that these results are not directly comparable because the last ones tried the assessment version and some of them wrote in the open-ended questions that they would like to have more information about the resolution of the cases, for instance the pathologies.

In the SUS questionnaire all the questions received scores 4 and 5, except two that had a median score of 3 and reveal that the users feel the usage of the application is somehow restrictive. This result is coherent with the mentioned small number of available situations to solve, also expressed in open-ended questions.

In the open-ended questions, 4th year students emphasized as positive aspects the possibility of interaction with the virtual patients resorting to a logic dialogue that support the training of the protocols (for instance, the correct sequence of questions to pose); they also enjoyed the possibility of choosing a particular character. The application was considered as a valid learning tool, adequate to help the learning process and to review the concepts explained in classes.

As a negative characteristic they mentioned the rapid end of the interaction with the patient when the student makes a mistake at the beginning of the case simulation.

The internships considered the prototype could become a powerful tool to learn and to consolidate knowledge, as long as it offers more situations. They mentioned that it can be a tool for students, but also for professionals that need to review and update their professional capacities: it can help remembering concepts and principles learned in school but already forgotten.

As negative aspects, they referred that real patients in pharmacy are usually not so predictable and sometimes not as civilized as the virtual ones in the application.

The majority of participants mentioned that a negative aspect is the very limited number of situations (just two, for the time being). All the participants agreed that the tool cannot substitute a real teacher, but it can be a good adjuvant learning tool, corroborating the opinion of the experts that tested the preliminary version of the prototype.

5 CONCLUSIONS AND FUTURE WORK

We developed and implemented an interactive application to support training and assessment of self-medication consultation skills in pharmacy students, using VHs animated with facial expressions, body movements and speech communication.

The abbreviated usability study allowed checking for potential advantages of using this software, clearly as an additional source of students' motivation to practice their counselling skills scenarios: students were optimistic in relation to move away from traditional paper-based clinical cases into a closer sense of professional interaction.

Another strong point of this prototype is its BackOffice web application, which can be operated by users without informatics skills. It allows instructors to develop the consultation dialogues in an intuitive and user-friendly graphical interface and provides data on students' performance.

The evaluation of pharmacy students was positive, both in terms of usability and usefulness. This is in accordance with experts' views, who were also of the opinion that the application could be used for postgraduate continuing education.

The overall results obtained are encouraging and justify the development of an improved version which will respond to most users' suggestions. Additionally we intend to include principles of "gamification", by adjusting the level of difficulty to the scores previously obtained. This may increase motivation of young students to use the application in the training mode. An escalation of difficulty relies, from a communication standpoint, in more variability in the VHs behaviour and in a wider range of simulated moods (for instance, less cooperating patients, more voice tones, more facial and body expressions).

Currently the application includes virtual humans speaking Portuguese and English, a feature we wish to maintain in the next version. In the near future, it is also our intention to widen the evaluation to pharmacy students and practitioners in Portuguese-speaking countries. This will certainly shed light on improvements and functionalities needed to yield versions that are appropriate for different countries and cultures.

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