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The use of virtual patients to teach medical students history taking and communication skills

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Abstract

Background: At most institutions, medical students learn communication skills through the use of standardized patients (SPs), but SPs are time and resource expensive. Virtual patients (VPs) may offer several advantages over SPs, but little data exist regarding the use of VPs in teaching communication skills. Therefore, we report our initial efforts to create an interactive virtual clinical scenario of a patient with acute abdominal pain to teach medical students history-taking and communication skills.

Methods: In the virtual scenario, a life-sized VP is projected on the wall of an examination room. Before the virtual encounter, the student reviews patient information on a handheld tablet personal computer, and they are directed to take a history and develop a differential diagnosis. The virtual system includes 2 networked personal computers (PCs), 1 data projector, 2 USB2 Web cameras to track the user's head and hand movement, a tablet PC, and a microphone. The VP is programmed with specific answers and gestures in response to questions asked by students. The VP responses to student questions were developed by reviewing videotapes of students' performances with real SPs. After obtaining informed consent, 20 students underwent voice recognition training followed by a videotaped VP encounter. Immediately after the virtual scenario, students completed a technology and SP questionnaire (Maastricht Simulated Patient Assessment).

Results: All participants had prior experience with real SPs. Initially, the VP correctly recognized approximately 60% of the student's questions, and improving the script depth and variability of the VP responses enhanced most incorrect voice recognition. Student comments were favorable particularly related to feedback provided by the virtual instructor. The overall student rating of the virtual experience was 6.47 ± 1.63 (1 = lowest, 10 = highest) for version 1.0 and 7.22 ± 1.76 for version 2.0 (4 months later) reflecting enhanced voice recognition and other technological improvements. These overall ratings compare favorably to a 7.47 ± 1.16 student rating for real SPs.

Conclusions: Despite current technological limitations, virtual clinical scenarios could provide students a controllable, secure, and safe learning environment with the opportunity for extensive repetitive practice with feedback without consequence to a real or SP. © 2006 Excerpta Medica Inc. All rights reserved.

Keywords: Communication skills; Standardized patients; Virtual reality; Virtual patients

Effective communication between practitioners and patients improves health care outcomes, whereas ineffective communication contributes to medical errors and malpractice litigation [1]. To underscore the importance of interpersonal

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and communication skills, licensing and accrediting organizations, such as the Liason Committee on Medical Education and Accreditation Council for Graduate Medical Education, have made these clinical skills a core competency for all medical student and residents.

Considerable institutional variability exists regarding how communication skills are taught and assessed in medical education. At many medical schools, communication skills are taught and tested through standardized patients (SPs). Despite the advantages over real patients, the use of SPs for teaching and testing clinical skills is both time and resource expensive. Computer simulation and virtual reality represent innovative educational tools. Virtual patients (VPs) may offer several advantages over SPs by providing a controllable, secure, and safe learning environment with the opportunity for extensive repetitive student practice with feedback without consequence to a real or SP. Unfortunately, little data exist regarding the use of VPs in teaching communication skills. Therefore, we report our initial interdisciplinary collaborative efforts to create an interactive virtual clinical scenario by using a life-sized VP and virtual instructor (VI) to teach medical students history-taking and communication skills.

Methods

Through an interdisciplinary collaboration at the University of Florida (UF), medical students, clinical faculty, professional educators, and computer scientists have created an interactive, life-sized virtual clinical scenario of a patient with acute abdominal pain (Fig. 1). The prototype scenario is directed at second-year medical students, recognizing that history-taking and communication skills are critical in the evaluation of a patient with abdominal pain. The virtual

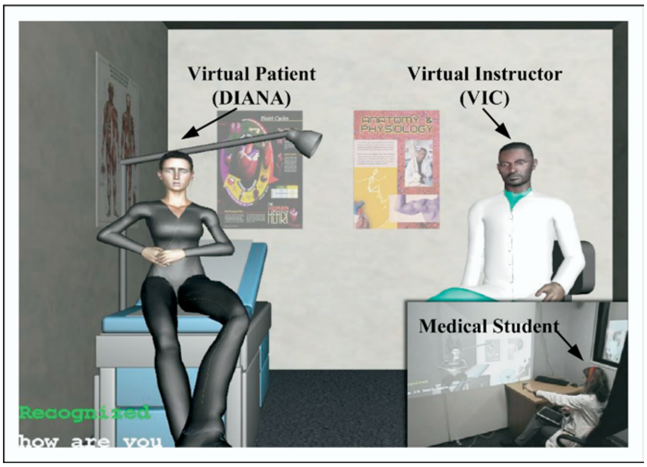

Fig. 1. The virtual scenario. A female virtual patient, DIANA, complains of abdominal pain. The instructor on the right, VIC, coordinates the diagnosis. (Inset) Student points to DIANA and asks, "Does it hurt here?" Confirmation of correct speech recognition is given in the lower left-hand corner of the screen.

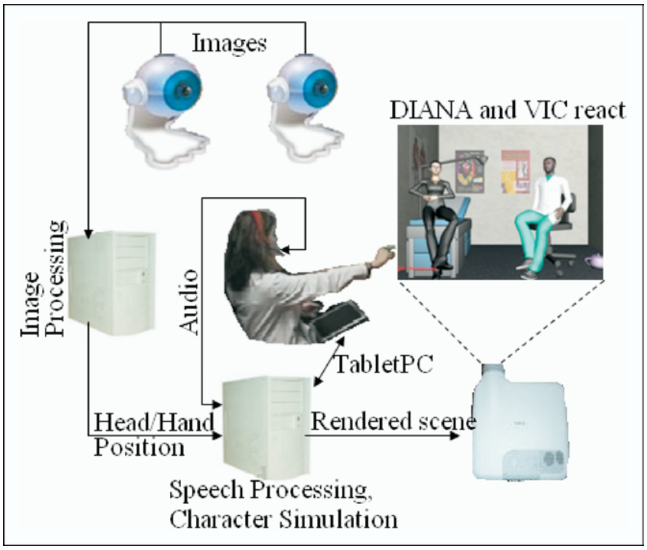

Fig. 2. System layout.

system includes 2 networked personal computers (PCs), 1 data projector, 2 USB2 Web cameras to track the user's head and hand movement, 1 tablet PC, and a microphone. The system also tracks the 3-dimensional trajectory of the student's hand and head with a marker-based tracking mechanism (Fig. 2). The technology used in the pilot study is readily available "off the shelf," and the entire prototype system cost less than $7,000.

In the virtual scenario, a life-sized VP (DIANA) is projected on the wall of a standard examination room in UF's Harrell Adult Development and Testing Center. In the scenario developed, the VP is a 19-year-old female college student who presents with acute abdominal pain (Fig. 1). Immediately before the virtual encounter, the student reviews basic information posted on the handheld tablet PC including the VP's name, age, gender, vital signs, and chief complaint. The student is instructed to take a history and develop a differential diagnosis. The VP is programmed with specific answers to questions based on phrases asked by students. The VI (virtual instructor) provides the initial goals of the exercise, and he also advises the student when 1 minute remains in the virtual interaction. He asks the student to provide a differential diagnosis at the end of the virtual interaction and provides learner feedback regarding the answers. Student gestures that were monitored in the study included (1) the attempt at shaking the hand of the VP and (2) pointing to the location of the abdominal pain and student head gaze (Fig. 1). Before beginning the VP interaction, the student spent 10 minutes with the computer to create a voice profile and students received basic instructions on how to communicate with a computer (ie, cues to use if the VP does not answer questions with voice recognition).

The UF Institutional Review Board granted approval for the initial pilot study, and informed consent was obtained from all participants (N = 20). All participants were also

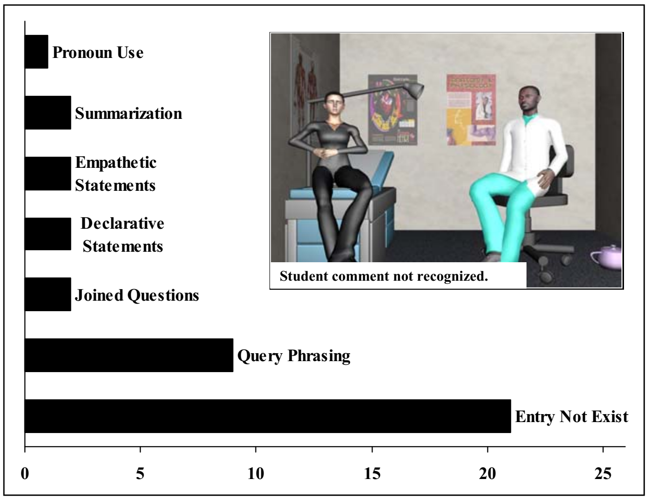

Fig. 3. Analysis of failures of the VP to recognize student questions. The VP's failure to recognize the student question is given in the lower left-hand corner of the screen.

videotaped and surveyed verbally and by a technology questionnaire (developed by the computer science collaborators) immediately after the encounter as an audience to improve the authenticity of the virtual clinical scenario. The Maastricht Simulated Patient Assessment was adapted for students to evaluate the VP interaction [2].

Results

Virtual patient recognition of student questions

Using our script-based approach, initially the VP successfully recognized approximately 60% of all student queries. Feedback regarding the VP's failure to recognize a student comment was provided in the lower left-hand corner of the screen prompting students to restate or rephrase their comment or question. Of note, in some student-VP interactions, the VP successfully recognized all student questions.

Figure 3 shows an analysis of VP failures to respond or incorrect responses to student questions. Student question-VP response mismatches included the following:

1. Entry not exist (21%): the majority of VP recognition failures were caused by students asking a question that lacked a scripted VP response. By enhancing the number of VP responses to student questions, this number decreased to less than 10% in the latter part of the study.
2. Query phrasing (9%): variations in how the students posed their questions accounted for approximately 9% of VP response failures. For example, the VP successfully recognized and responded appropriately to the question "Have you had a fever?" but the VP failed to recognize this question when was posed as "Are you feeling feverish?
3. Joined 1uestions (2%): the student connected multiple questions within a question. For example, "Have you had any nausea or bowel problems?"
4. Declarative statements (2%): with the current technology, the VP assumes all student speech is in a question format. The VP had difficulty recognizing long declarative statements with voice inflection at the end suggesting a leading question. For example, "Hello DIANA, I am a second-year medical student here to ask you some questions. I understand you are experiencing abdominal pain, correct?"
5. Empathetic statements (2%): interestingly, students responded to the VP's abdominal pain with empathetic statements that validated the VP feelings such as "I understand how this can be scary for you." Although effectively communicating empathy is an important component of the doctor patient relationship, the VP had difficulty recognizing these statements.
6. Incomplete sentences (2%): the VP infrequently responded prematurely when students paused in the middle of a sentence.
7. Pronoun use (2%): for example, "How many days have you had that?" Completing a sentence with "that" without being specific regarding what "that" refers to made it difficult for the VP to respond appropriately.
8. Summary statements (1%): for example, "let me check to see if I understand, you have been feeling this pain for approximately 24 hours?" Restating what the patient has said during the medical interview to clarify the information received is an important information-gathering skill. Unfortunately, the VP had difficulty responding to these summary statements.

Student evaluation of the virtual scenario

All students had experience with SPs in teaching and testing with an average of 2 performance-based examinations per medical student. The student survey responses regarding the virtual interaction appear in Tables 1 and 2. The survey instrumentation used in Table 1 was validated in

Table 1
Student standardized patient survey

Survey statement* (N = 20)	Response†
The virtual patient (VP) appears authentic.	3.95 ± 0.76
The VP stimulates the student to ask questions.	3.75 ± 0.99
I would use the virtual scenario to practice my clinical skills.	4.25 ± 0.79
The virtual instructor's feedback is helpful.	4.25 ± 1.16
Mean overall score	4.00 ± 0.76

* Representative statements from a 15-item survey (Maastricht SP Assessment).
† Five-point Likert-type scale (1 = strongly disagree, 5 = strongly agree).

Table 2
Student technological survey

Survey statement* (N = 20)	Response†
I had a sense of "being there" in the virtual exam room.	5.12 ± 0.89
The importance of the VP being life-sized.	6.33 ± 1.21
The quality of the speech recognition.	6.71 ± 0.49
The VP gestures were life-like.	5.67 ± 1.33
Mean overall score	6.47 ± 1.63

* Representative statements from a 15-item technological survey.
† Ten-point Likert-type scale (1 = least important, 5 = most important).

a previous study of real SPs. Figure 4 shows the overall student rating of the first version of the virtual scenario (VP, version 1, n = 7), a second version 4 months later (VP, version 2, n=13) after the incorporation of several student suggested improvements and the student rating of a real SP. Students were also interviewed after the virtual scenario, and selected students' comments appear in Table 3.

Student gaze tracking

Figure 5 shows tracking of the students gaze at the VP. The red-pink dots surrounding DIANA's head indicate when the student's head was pointed in the VP's direction.

Comments

Computer simulation and virtual reality may represent the future of teaching and assessment. Virtual technology could overcome many of the current challenges in teaching communication skills. Virtual patients may offer several advantages over SPs including: (1) limiting variability and expense associated with SP training; (2) creating an almost limitless repository of diverse and challenging virtual clinical scenarios (ie, the aggressive patient or poor historian) that are difficult to duplicate with authentic SPs (ie, infants, children, gender, ethnicity, and cultural characteristics); (3) maintaining a computerized log of student progress with objective performance data; (4) tailoring educational methods to fit individual student learning styles and rates of progress; and (5) providing a controllable, secure, safe learning environment with the opportunity for extensive repetitive practice with feedback from a virtual instructor.

Unfortunately, there is almost no data regarding the use of VPs in medical education. Virtual characters have been successfully used to train military personnel [3] and to create a virtual audience to lessen the fear of public speaking [4]. These studies and others have shown that life-sized virtual interactions produce emotional effects that are comparable to real interactions [5]. Emotions such as embarrassment, fear, irritation, anxiety, and self-awareness can be elicited in real people by virtual characters. Investigators at the Research Triangle Institute recently verified that VPs, depicted as 3-dimensional virtual characters with natural speech displayed on a monitor, could have substantial emotional effects on medical students [6]. To our knowledge, no published literature exist the specifically examines the use of virtual patients in teaching and assessing communication skills.

Proficient information exchange between physicians and patients improves health care outcomes and patient satisfac-

Table 3
Selected student debriefing comments

Student comments
"It allows students to ask questions without being nervous about actually talking to a real human being, which is a common problem with first and second years."
"First years don't get a chance to interview standardized patients at all. Virtual system would be a good introduction to interviewing for first and second years."
"Vic's feedback at the end was great! Really helpful."
"I felt like at times she didn't answer the questions I asked"
"If the VP doesn't answer the question which inevitably happens in real life too, it forces you to think about other ways to ask the question."

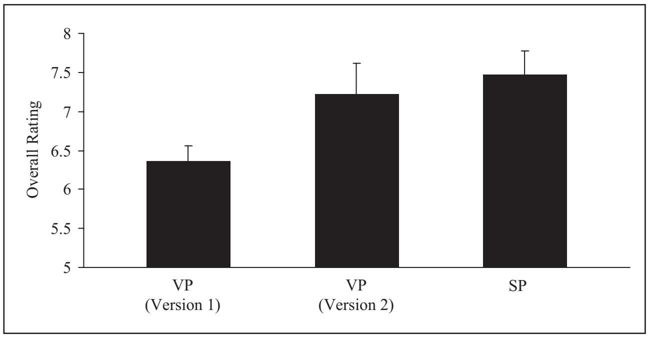

Fig. 4. Overall student rating of virtual scenario. VP (version 1, n = 7) represents the first version of the virtual scenario. VP (version 2, n = 13) is a second version 4 months after the incorporation of several student suggestions for improvement. SP represents student rating of a real SP.

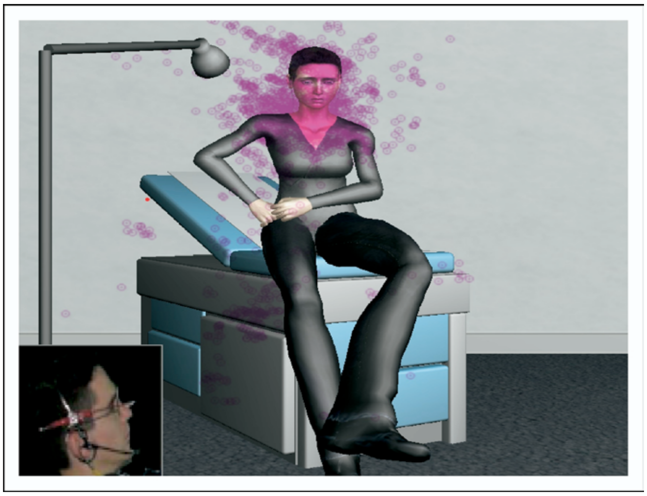

Fig. 5. Student gaze tracking. The red-pink dots surrounding DIANA's head indicate when the student's head was pointed in the VP's direction.

tion [7]. Effective communication is a core clinical skill that can be taught, learned, and practiced. The sole reliance on experiential learning of communication skills is inadequate, and it may reinforce and perpetuate bad clinical habits. Furthermore, medical students' abilities to communicate effectively may deteriorate as they proceed through their postgraduate training (personal observation). The systematic delineation and definition of the essential elements of effective communication skills is essential to teach and assess this core competency. Regrettably, teaching and testing communication skills have not received sufficient dedicated time in an already overcrowded medical school curriculum. The recent emphasis on communication skills as a core competency throughout the continuum of medical education demands effective methods of teaching and testing tools for this critical competency.

In this report, we describe our initial interdisciplinary efforts to create and evaluate a highly immersive interaction with a virtual patient as a method to teach medical students basic communication skills. Using a script matching approach, initially the VP failed to recognize several student queries. Our categorization of VP failures revealed that the majority of failures were because of an incomplete VP script. Based on these observations, the script was enhanced by reviewing medical student:SP interactions digitally archived in UF's Harrell Professional Development Center. These script revisions led to a greater than 90% recognition rate in subsequent medical student:VP interactions. Although 100% recognition is probably not feasible, it is likely that less than perfect matching between the student and VP will not impair learning objectives of the virtual interaction. Some students did become frustrated with the VPs occasionally answering questions incorrectly or repeated previous answers. On the other hand, some students believed that the virtual experienced closely mimicked the real doctor: patient interaction. During an actual medical interview, physicians are frequently required to restate or rephrase questions and statements. This repetition assists in clarifying correct information transfer. Therefore, future versions of the virtual scenario will incorporate a default VP response to unrecognized student comments that resemble real patient responses such as " Can you please repeat that I did not hear you."

In general, students were enthusiastic about the virtual interaction and its value as a teaching tool. In addition, their overall evaluation of the virtual scenario increased with subsequent versions as learner-centered suggestions for improvement were incorporated. Most students believed the virtual interaction would aid in their preparation for interaction with standardized and real patients. The use of a virtual instructor to provide timely, nonjudgmental, specific feedback regarding the student's performance is a potentially powerful educational tool. Students frequently complain about a lack of constructive feedback to guide their learning particularly in SP encounters. Our scenario offers the opportunity to study which elements are most important to produce desired learning outcomes. We believe that natural interaction (ie, voice, gesture recognition with life-sized virtual characters) increases the level of student immersion rather than scenarios that use PC screen–sized characters, a keyboard, and mouse. Future efforts are directed at developing and evaluating methods to increase the level of immersion of our virtual scenario.

The study is limited in that the scenario chosen was highly constrained in order to permit the script-based speech recognition mechanism to perform adequately. Current technological limitations limit the use higher order communication skills such as empathy, negotiation, and conveying bad news.

The effective use of appropriate nonverbal communication skills (ie, eye contact, posture, head nods, appropriate distance, and gestures) is positively related to patient satisfaction [8]. The student gaze tracking shown in Figure 5 represents our preliminary efforts to develop metrics to measure appropriate student use of nonverbal communication skills. Students should gaze toward the VP during most of the medical interview, particularly when the VP is speaking. Ultimately, we hope to measure several effective verbal and nonverbal communication skills and allow the VI to provide constructive learner feedback regarding their use in the virtual scenario. Ongoing efforts also are directed toward validating the virtual scenario through a concurrent comparison of VPs to SPs. In addition, there are future plans to fully integrate the virtual patient into the medical student curriculum to supplement the use of SPs in teaching communication skills.

Although our initial efforts have appropriately focused on using the virtual scenario as a teaching tool, with technological improvements, virtual scenarios could be used for performance-based testing. The development of multiple virtual clinical scenarios (ie, headache, dizziness, blood per rectum, and so on) could lead to a virtual corollary to the Objective Structured Clinical Examination, the Virtual Objective Structured Clinical Examination. The Virtual Objective Structured Clinical Examination could represent a cost savings, in fixed-model, high-stakes clinical skills examinations (ie, the NBME Step 2 Clinical Skills Examination).

References

[1] Duffy FD, Gordon GH, Whelan G, et al. Assessing competence in communication and interpersonal skills: The Kalamazoo 2 report. Acad Med 2004;79:495–507.

[2] Wind LA, Dalen JV, Muijtjens AM, Rethans J. Assessing simulated patients in an educational setting: The MaSP (Maastricht Assessment of Simulated Patients). Med Educ 2004;38:39–44.

[3] Hill R, Gratch J, Marsella S, et al. Virtual humans in the mission rehearsal exercise system. Kynstliche Intelligenz (KI) Journal. Special issue on embodied conversational agents. 2003.

[4] Pertaub D, Slater M, Barker C. An experiment on public speaking anxiety in response to three different types of virtual audience. Presence: Teleoperators and Virtual Environments 2001;11:68–78.

[5] Bearman M, Cesnik B, Liddell M. Random comparison of 'virtual patient' models in the context of teaching clinical communication skills. Med Educ 2001;35:824–32.

[6] Hubal R, Kizakevich P, Merino D, West S. The virtual standardized patient: simulated patient-practitioner dialogue for patient interview training. In: Westwood JD, Hoffman HM, Mogel GT, et al, eds. *Envisioning Healing: Interactive Technology and the Patient-Practitioner Dialogue*. Amsterdam: IOS Press, 2000.

[7] Cegala DJ, Broz SL. Physician communication skills training: a review of theoretical backgrounds, objectives and skills. Med Educ 2002;36:16–1004.

[8] Haq C, Steele DJ, Marchland L, et al. Integrating the art and science of medical practice: innovations in teaching medical communication skills. Fam Med 2004;36:s43–50.