Title:

THE USE OF VIRTUAL PATIENTS TO TEACH MEDICAL STUDENTS HISTORY TAKING AND COMMUNICATION SKILLS.

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KEY WORDS

Communication Skills, Standardized Patients, Virtual Reality, Virtual Patients

SUMMARY SENTENCE

At most institutions, medical students learn communication skills through the use of standardized patients (SP's). Virtual patients (VP's) may offer several advantages over SP's, but little data exists regarding the use of VP's 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.

ABSTRACT

Background: At most institutions, medical students learn communication skills through the use of standardized patients (SP's), but SP's are time and resource expensive. Virtual patients (VP's) may offer several advantages over SP's, but little data exists regarding the use of VP's 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 exam room. Before the virtual encounter, the student reviews patient information on a hand-held tablet personal computer and they are directed to take a history and develop a differential diagnosis. The virtual system includes two networked personal computers (PC's), one data projector, two USB2 web cameras to track the users head and hand movement, a tablet PC, and a microphone. The VP is programmed with specific answers and gestures in response to questions asked and gestures performed by students. Queries to responses were developed by faculty and enhanced by reviewing videotapes of students' performances with real SP's. Immediately following the virtual scenario, students (N=20) completed a technology and SP questionnaire (Maastricht Simulated Patient Assessment).

Results: All participants had prior experience with real SP's. Initially, the VP correctly recognized more than 60% of the student's questions and most incorrect voice recognition was not due to technological limitations but was enhanced by improving the scenario depth and variability of the VP responses. Student comments were favorable particularly related to feedback provided by the virtual instructor (VI). The overall student rating of the virtual experience was 6.47±1.63 (1= lowest, 10 = highest) for version 1 and 7.22±1.76 for version 2 (4 months later) reflecting enhanced voice recognition and other technological improvements. These overall ratings compare favorably to a 7.47±1.16 rating for real SP's.

Conclusions: Despite current technological limitations, virtual clinical scenarios could provide a controllable, secure, and safe learning environment with the opportunity for extensive repetitive practice with feedback without consequence to a real or SP.

INTRODUCTION

Effective communication between practitioners and patients improves health care outcomes, while ineffective communication contributes to medical errors and malpractice litigation [1]. To underscore the importance of interpersonal and communication skills, licensing and accrediting organizations, such as the LCME and ACGME, 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 assessed through standardized patients (SP's). Despite the advantages over using real patients, the use of SP's for teaching and testing clinical skills is both time and resource expensive. Computer simulation and virtual reality (VR) may represent the future of teaching and assessment. Virtual patients (VP's) may offer several advantages over SP's 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 exists regarding the use of VP's in teaching communication skills. Therefore, we report our initial interdisciplinary collaborative efforts to create an interactive virtual clinical scenario using a life-sized VP and virtual instructor 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 created an interactive, life-sized virtual clinical scenario of a patient with acute abdominal pain (Figure 1). The prototype scenario is directed at the second-year medical student level, recognizing that history-taking and communication skills are critical in the evaluation of a patient with abdominal pain. The virtual system includes two networked personal computers (PC's), one data projector, two USB2 web cameras, tablet PC, and a microphone. The system also tracks the three-dimensional motion of the student's head and hand with a marker-based tracking mechanism (Figure 2). The technology used in the pilot study is readily available "commercoal-off-the-shelf" (COTS) equipment, and the entire prototype system cost less than $10,000.

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 (Figure 1). Immediately prior to the virtual encounter, the student reviews information posted on the hand-held tablet PC. The examinee receives specific instructions that indicate the patient's name, age, gender, and reason for visiting the doctor. Information also indicates her vital signs, including heart rate, blood pressure, temperature, and respiratory rate. The student directions include taking a history and developing a differential diagnosis. The VP is programmed with specific answers to questions based on phrases asked by students. The virtual instructor (VI, VIC) provides immediate specific, formative and summative learner feedback and he also advises the student when 1-minute remains in the virtual interaction. Two gestures that were recognized in the study were the attempt at shaking the hand of the VP (by the student

extending their hand in front of their body) and pointing to the location of the abdominal pain (Figure 1). Prior to beginning the VP interaction, the student spent 10 minutes with the system to create a voice profile and received basic instructions on how to communicate with the system (i.e. cues to use if the VP does not answer questions with voice recognition).

The University of Florida Institutional Review Board granted approval for the initial pilot study and informed consent was obtained on all participants (N=20). The Maastricht Simulated Patient Assessment was adapted for students to evaluate the VP interaction [2]. Participants were videotaped and surveyed verbally and by questionnaire immediately post encounter as an audience to improve the authenticity of the virtual clinical scenario.

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. Students were therefore prompted to rephrase their comment or question. Of note, in some student-VP interactions the VP successfully recognized all student questions.

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

Entry Not Exist (21%) – The majority of VP recognition failures were due to students asking a question that lacked a scripted VP response. By enhancing the number of VP responses to student questions this number decreased substantially in the latter part of the study.

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?

Joined Questions (2%) – The student connected multiple questions within a question. For example, "Have you had any nausea or bowel problems?"

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 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?"

Empathetic Statements (2%) – Interestingly, much like a real patient, students responded to the VP's abdominal pain with empathetic statements that validated the VP feelings. For example, "I understand how this can be scary for you". While effectively communicating empathy is an important component of the doctor patient relationship, our VP had difficulty recognizing these statements

Incomplete Sentences (2%) – The VP infrequently responded prematurely when students interrupted or paused in the middle of a sentence

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.

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 SP's in teaching and testing with an average of two performance-based exams (PBE's) per medical student. The student survey feedback regarding the virtual interaction appears in Tables 1 and 2. The survey instrumentation used in Table 1 was validated in a previous study of real SP's. Figure 3 shows the overall student rating of the first version of the virtual scenario (VP, version 1), a second version 4 months later (VP, version 2) following the incorporation of several suggestion student improvements and the student rating of a real SP. Students were also interviewed following the virtual scenario and selected students comments appear below:

“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 2nd 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 2nd years.”

“Vic's feedback at the end was great! Really helpful. .”

Some students did become frustrated with the VP’s occasionally answering questions incorrectly or repeated previous answers as evidenced by this comment:

“I felt like at times she didn’t answer the questions I asked”

On the other hand some students felt that the virtual experienced closely mimicked the real doctor: patient interaction as evidenced by this comment:

“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.”

Student Gaze Tracking

Figure 5 demonstrates 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.

Table 1
Student Standardized Patient Survey

Survey Statement[#] (N=20)	Response[*]
The virtual patient (VP) appears authentic.	3.95±0.76
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).
[*]5-point Likert-type scale (1=Strongly Agree, 5=Strongly Disagree)

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.
[*]7-point Likert-type scale (1=Least Important, 7=Most Important)

DISCUSSION

Computer simulation and virtual reality (VR) 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 SP's including: 1) limiting variability and expense associated with SP training, 2) creating an almost limitless repository of diverse and challenging virtual clinical scenarios (i.e. the aggressive patient or poor historian) that are difficult to duplicate with authentic SP's (i.e. infants, children, gender, ethnicity, 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, 5) providing a controllable, secure, safe learning environment with the opportunity for extensive repetitive practice with feedback from a virtual instructor. Combining the VP with a VI permits immediate, specific, nonjudgmental feedback to the learner.

Unfortunately, there is almost no data regarding the use of VP's 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 demonstrated that 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 (RTI) recently verified that VP's, depicted as three-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 healthcare outcomes and patient satisfaction [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 habits. Systematic delineation and definition of the essential elements of effective communication skills is essential. Regrettably, teaching and testing communication skills have not received sufficient dedicated time in an already overcrowded medical school curriculum. Furthermore, medical students' abilities to communicate effectively may deteriorate as they proceed through their training (personal observation). The renewed 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 due to an incomplete script. Based on these observations, the script was enhancement performed by scrutinizing digitally archived medical student: SP interactions. These script revisions led to a greater than 90% (XXX) recognition rate in subsequent medical student: VP interactions. Although 100% recognition is probably not feasible, it is likely that less than perfect matching of the students' queries will not impair learning objectives of the interaction. Furthermore, as evidenced by the student comments, in the medical interview with a real patient, doctors are frequently required to restate or rephrase questions and statements. 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 felt the virtual interaction would aid in 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 (i.e. voice, gesture recognition with life-sized virtual characters) increases the level of student immersion rather scenarios that employ PC screen-sized characters that require a keyboard and mouse for use. 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 relatively crude 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 nonverbal communication skills (i.e. 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. 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 towards validating the virtual scenario through a concurrent comparison of VP's to SP's. In addition, there are future plans to fully integrate the virtual patient into the medical student curriculum.

While 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. Developing multiple virtual clinical scenarios could lead to a virtual corollary to the Objective Structured Clinical Examination or OSCE - the Virtual Objective Structured Clinical or VOSCE. Ultimately, the VOSCE would represent a cost-savings, in fixed-model, high-stakes clinical skills examinations (i.e. the NBME Step 2 Clinical Skills Examination).

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FIGURE LEGENDS

Figure 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.

Figure 2. System Layout.

Figure 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.

Figure 4. Overall Student Rating of Virtual Scenario.

Figure 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.

Figure 1

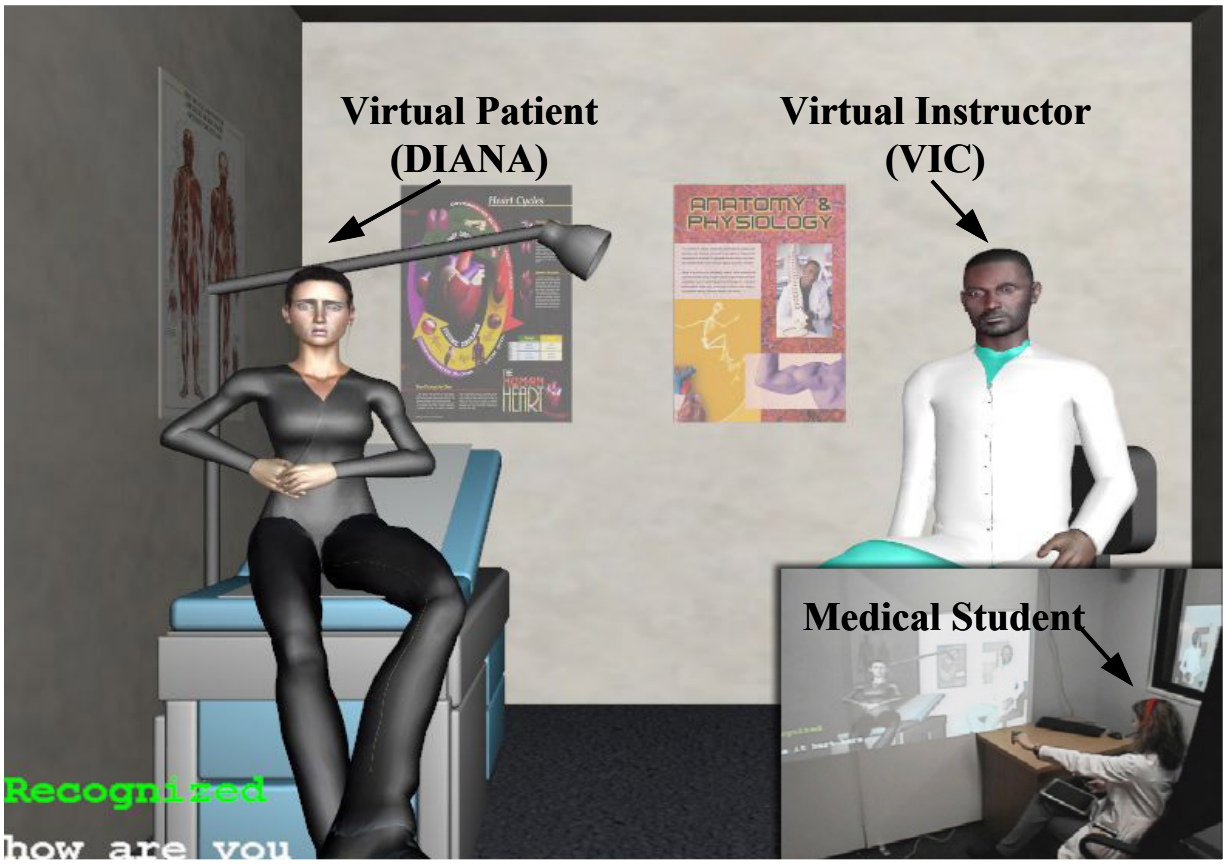
Virtual Patient
(DIANA)
Virtual Instructor
(VIC)
Medical Student
Recognized
how are you

Figure 2

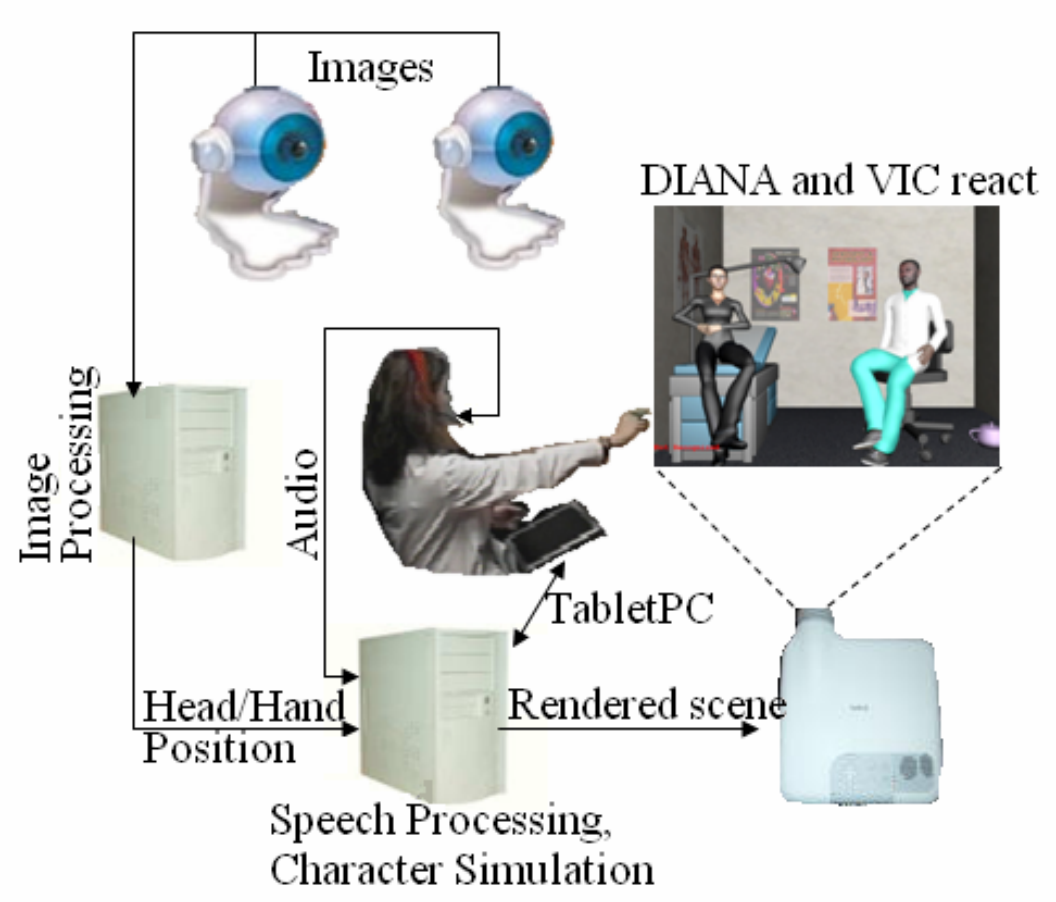
Images
DIANA and VIC react
Image Processing
Audio
TabletPC
Head/Hand Position
Rendered scene
Speech Processing, Character Simulation

Figure 3

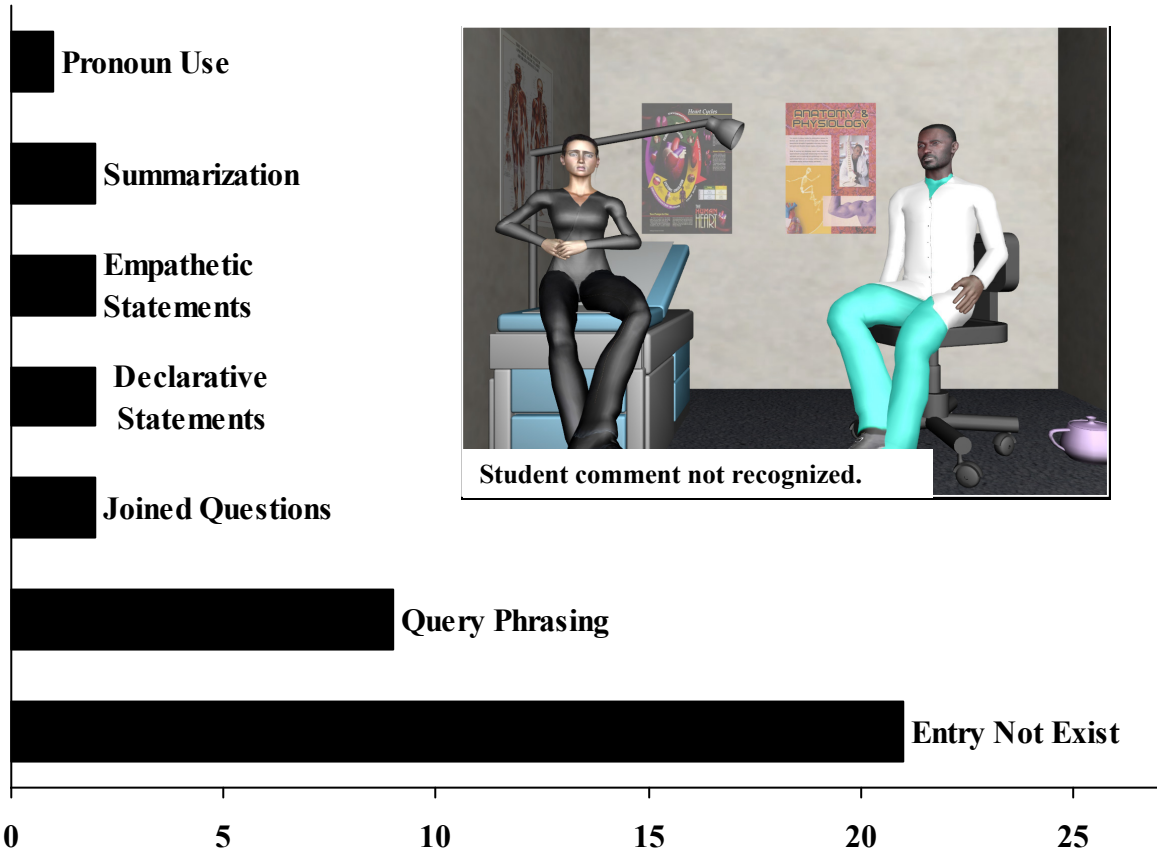
Pronoun Use
Summarization
Empathetic Statements
Declarative Statements
Joined Questions
Query Phrasing
Entry Not Exist
0
5
10
15
20
25
Student comment not recognized.
ANATOMY & PHYSIOLOGY

Figure 4

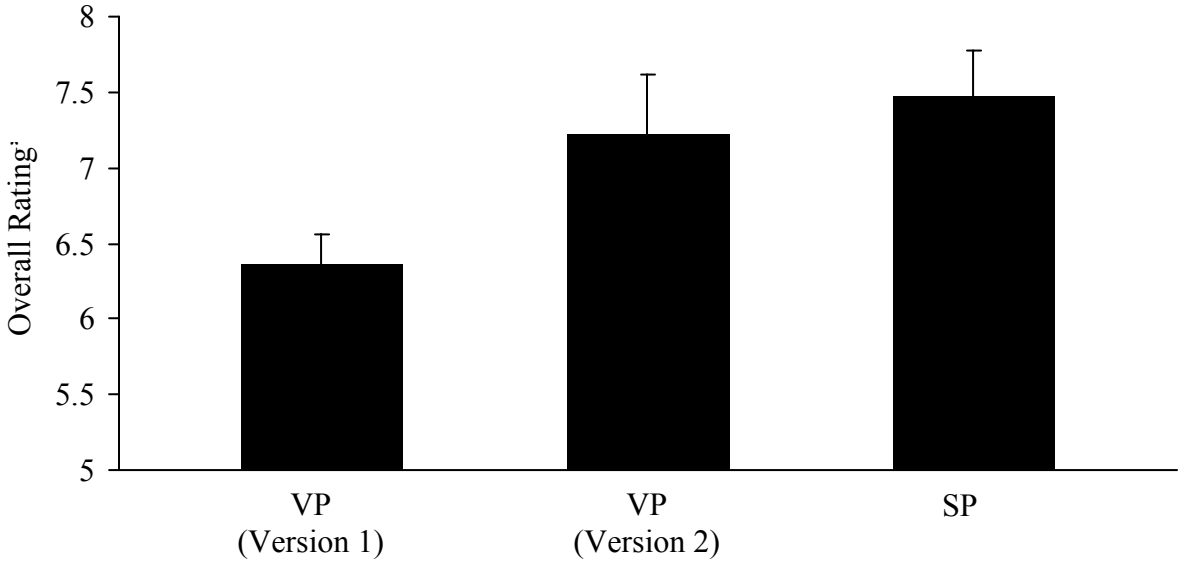

Figure 5