Engineering Social Agent Creation into an Opportunity for Interviewing and Interpersonal Skills Training

Socially Interactive Agents Track

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ABSTRACT

The use of intelligent, interactive social agents for clinical interviewing and interpersonal skills training in healthcare education has been observed to be on the increase. However, enabling rapid and scalable creation of robust and diverse intelligent social agents that can be integrated into educational curriculum for pedagogical reasons is still a challenge. In this paper, we present a novel approach for creating virtual patients (social agents that play the role of a patient) by reusing conversational corpus information from previous student-created interactive social agents. In this approach, healthcare students as part of an interpersonal skills training exercise create their own virtual patients. These virtual patient agents created are demonstrated to be effective tools to train other students in the future with their interviewing and interpersonal skills. By integrating virtual patient creation exercises in seven health professions courses over six years, we have demonstrated that healthcare students can create robust and diverse virtual patient social agents that can be used as pedagogical tools and in the process of creation also improve their own clinical interviewing and interpersonal skills.

KEYWORDS

virtual social agents; embodied conversational agents; virtual patients; constructionism; interpersonal skills training; healthcare education

ACM Reference Format:

Shivashankar Halan, Isaac Sia, Anna Miles, Michael Crary, and Benjamin Lok. 2018. Engineering Social Agent Creation into an Opportunity for Interviewing and Interpersonal Skills Training. In *Proc. of the 17th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2018), Stockholm, Sweden, July 10–15, 2018,* IFAAMAS, 9 pages.

1 INTRODUCTION

Virtual social agents are computer-generated characters that can hold natural language conversations with users and/or with each other. These social agents are often embodied as *virtual humans* - social agents designed to look, speak and behave like a real human. Virtual humans are predominantly deployed in simulations for enabling the user to feel like he or she is occupying the same space as another human or interacting with another human [1] [13]. Conversational virtual humans have been successfully used for interpersonal skills training [13] [15] [14] [5]. Simulations with interactive virtual humans for interpersonal skills training provide a safe environment for trainees to practice interacting with other humans under stressful or high-stakes scenarios [24] [17]. For example, a healthcare student can use a virtual human simulation to practice breaking the news to a patient that he or she has cancer [2] [18]. Similarly, a military officer can practice negotiating with residents of a foreign country to elicit their cooperation to conduct a military operation in the area [15] [14].

In this paper, we focus on the specific application domain of healthcare education and the use of virtual humans for training healthcare students with their interpersonal and clinical interviewing skills. The applicability of using *virtual patients* - social agents that play the role of a patient during interactions - has been well studied and established [4] [13] [14]. Virtual patient simulations typically simulate the medical interview enabling healthcare students to practice interviewing patients. A screenshot of a sample virtual patient interaction is shown in Figure 1 below.

The agents used in virtual patient-based simulations are question-answering social agents - they respond with information to natural language questions or statements made by the interviewer. In these virtual patient simulations, healthcare students interact with the virtual patient by posing questions or making statements. The virtual patient responds with natural language text, audio, video and animations to the user's questions. The goal of these simulations is to create the experience of interviewing a real patient. The goal for the healthcare student is to elicit information from the patient efficiently and using this information to make an accurate diagnosis.

Virtual patients that are used in interpersonal skills training simulations for healthcare students need to be robust and diverse. A question-answering social agent is robust if he or she can simulate a realistic interaction with the interviewer by providing information accurately in response to the interviewer's questions. Virtual patients need to be robust so that they can accurately simulate the experience of interacting with a real patient. Virtual patients

Proc. of the 17th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2018), M. Dastani, G. Sukthankar, E. André, S. Koenig (eds.), July 10–15, 2018, Stockholm, Sweden.

Figure 1: Screenshot of a typed natural language interaction with a virtual patient with a sample transcript.

also need to be diverse because interpersonal skills training often requires healthcare students to interact with virtual patients of different etiologies, gender, race, age and background [19].

Although the validity of using virtual patients for interviewing and interpersonal skills training has been well established [13] [14] [24], creating these virtual patient social agents is still a costly and time-consuming exercise [22] [23]. The reason for this is twofold. Firstly, the knowledge required to create robust virtual patient characters, that accurately depict the symptoms of an etiology, lies with domain experts like healthcare professionals and students. These experts have limited time available to share this knowledge in between their clinical duties and coursework. Secondly, there is a lack of systems that enable experts to create the virtual patients themselves. Experts must rely on computer or knowledge engineers to gather the knowledge from them and then create a virtual patient. These two reasons together make robust and diverse virtual patient creation a challenge [23].

To address this challenge, we propose a novel approach through which healthcare students can create their own virtual patients to be used for training future students, while improving their own interpersonal skills as part of the creation process. Previously published research indicates that certain critical interpersonal skills like empathy can be best taught by immersing the student in the perspective of the patient [10] [9] [11] [16] [8]. To achieve this, researchers have identified that healthcare students can learn clinical interviewing and interpersonal skills by creating their own virtual patients [7] [11] [9]. While creating their own virtual patient, students are forced to think from the perspective of the patient. This allows for them to reflect from the patient's perspective and understand important concepts like empathy and the need for identifying concerns with the patients [?] [3]. Students creating their own robust virtual patients is made possible in our approach by reusing conversational corpus information from previously completed virtual patient creation and interviewing exercises.

To evaluate the feasibility of our proposed approach, we integrated virtual patient creation exercises into seven healthcare courses over the duration of six years. 138 students registered as part of these courses over the six years created the conversational content for 136 virtual patient agents. Virtual patients created by these students were used in interpersonal skills training exercises with other healthcare students who demonstrated improved clinical interviewing skills by interacting with these virtual patients.

2 RELATED WORK

Constructing a conversational virtual human involves the creation of several aspects of the virtual human [12]. Some examples of virtual human components that need to be designed and created for an interactive virtual human include:

- **Appearance**: How the virtual human looks, including gender, ethnicity, body dimensions and clothing
- **Conversational capabilities**: How the virtual human responds to the interviewer's comments or questions, eg. dialogue and tone
- **Behavioral capabilities**: How the virtual human behaves during an interaction including animations, postures and eye gaze

For the research reported in this paper, we are primarily interested in the conversational capabilities modeling or verbal/dialogue aspect of virtual human creation. Conversational or dialogue modeling can be achieved using several different modeling mechanisms [20] [23]. One such method is by creating a conversational corpus. The corpus of a conversational virtual human consists of question-response pairs of what the users will say to the virtual human (questions) and what the virtual human will say back (response). When a user asks a question, the system searches the corpus for the most similar question and provides the paired answer. For example, if a user asked the virtual human "*Why are you here today?*", "*What's wrong?*", or "*How can I help you?*" the virtual patient would respond with "*I have problems swallowing my food*". The corpus-based approach is used predominantly to build question-answering virtual humans. Question-answering virtual humans can also from time-to-time make their own comments or statements, but majority of the interaction time with these virtual humans is spent providing responses to the interviewer's questions. These types of social agents are well suited for applications where information is provided on demand to users or in training simulations where the goal is to elicit information from the social agent.

3 PROPOSED METHODOLOGY FOR ROBUST VIRTUAL PATIENT CREATION

The proposed methodology for scalable virtual patient creation is illustrated in Figure 2 below. The methodology is based on reusing conversational corpus information from previous student-created virtual patients and previously completed student interactions with virtual patients. To understand the proposed methodology, we need to understand the challenges that limit the rapid creation of robust and diverse virtual patients. Most of the time that is spent creating a conversational corpus is taken up by coming up with alternate phrasings for the same question that can elicit some piece of information from the virtual patient. For example, consider our virtual patient Vinny Devito. Vinny Devito will respond to the questions "*What is your name?*" with "*My name is Vinny Devito*". However, there are at least twenty other ways in which the same information can be elicited from Vinny. Some example alternate phrasings are "*Can you please tell me your name?*", "*Tell me your name please*" or "*Hello, I am Mr. X*". Having to come up with these alternate phrasings for each virtual patient is a major challenge for creating virtual patient conversational corpora [23] [26].

The secondary challenge for creating conversational corpora is knowing what questions the virtual patient needs to be able to respond to. Even domain experts like healthcare instructors sometimes find it hard to estimate the questions that novice healthcare students will ask during a medical interview. Therefore, to address both these challenges, we propose mining data from student-created virtual patients and their interaction transcripts to generate a virtual patient template. This template will have pre-populated, the most frequent questions asked during medical interviews by students and their corresponding alternate phrasings. The template reduces the need for the creator to come up with all the alternate phrasings that can elicit response and focus only on coming up with the response itself. The proposed methodology is a five-step process as explained below.

3.1 Step 1 : Manual creation of a virtual patient

The first step in this creation methodology is creating a virtual patient conversational corpus manually by populating the responses and questions along with their alternate phrasings. When we start this process, we do not have any prior knowledge about the content of the virtual patient or what questions will be asked of said virtual patient. So, the first step would be to approach a domain expert, typically a healthcare education instructor, and create a first version of the virtual patient by guessing what questions and responses should go into making the virtual patient.

3.2 Step 2: Virtual patient interactions

To reduce the burden associated with coming up with all the alternate phrasings for the questions included in the first version of our patient, we crowdsource the process. We find other healthcare education experts, instructors or volunteer students to interact with the virtual patient that was created with the help of the domain expert in Step 1. As these other people interview our virtual patient, we gather what questions are unanswered or inaccurately answered by our virtual patient. When a question is unanswered or inaccurately answered it might be because of two reasons: the requested information was not included in our virtual patient or the information was present, but the phrasing used by the interviewer was not included in our virtual patient. By reviewing and addressing the list of unanswered questions after each interview with the virtual patient, we can iteratively improve the virtual patient conversational corpus by adding new responses or new alternate phrasings to questions. This process of iteratively improving the conversational corpus of the virtual patient is called as Human-centered Distributed Conversational Modeling (HDCM) [22] [23]. HDCM was shown to be able to create robust conversational corpora and take only 10% of the time taken by previous conversational modeling techniques [22]. By using HDCM and iterative refinement, we can create a robust first virtual patient and accumulate a set of interaction transcripts with the virtual patient.

Although HDCM is effective for cutting down the time taken for creating the virtual patient corpus, it cannot be used by healthcare students for creating their own virtual patients. The reason is that although the corpus creation time is reduced when compared to previous approaches, it still requires several tens of hours of expert time for corpus creation [23]. More importantly, the process is dependent on having others interview the virtual patient to improve the virtual patient. For these reasons, although HDCM is useful for creating a first version of our virtual patient, we use other conversational knowledge reuse methods to enable healthcare students to create their own virtual patients.

3.3 Step 3: Virtual patient template creation

Now that we have a single robust virtual patient created through Step 2 and interaction transcripts from others interviewing the virtual patient, we can create a virtual patient template of the most common questions and their alternate phrasings. A virtual patient template is a collection of all the commonly asked questions collected from previous virtual patients and transcripts. The alternate phrasings for each question is already pre-populated in the template to reduce the time for conversational corpus creation. The patient template only has the questions populated, the responses are left blank to be filled in by the healthcare student during the next step. A sample virtual patient template constructed from our course integrations is shown in Figure 3 above. To identify the most frequent questions asked during interviews with the virtual patient,

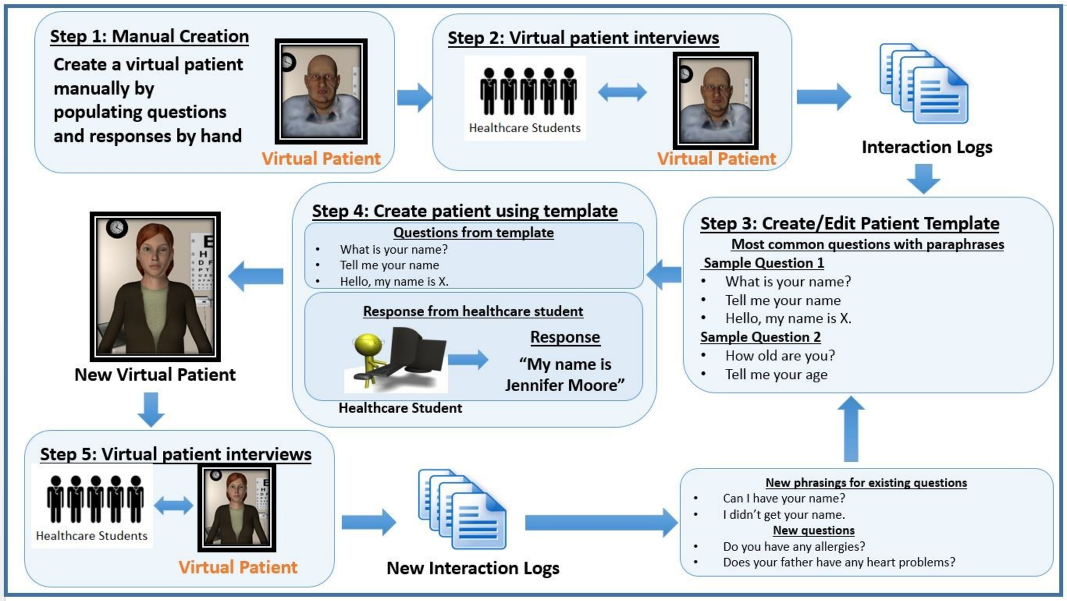

Figure 2: Illustration of the proposed methodology for scalable virtual patient creation.

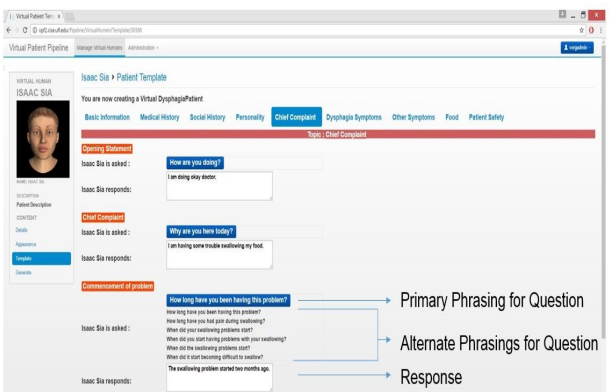

Figure 3: Screenshot of question-response pairs from the virtual patient template used in the course integrations

we performed a frequency analysis on the transcripts of students interacting with the virtual patient. Any question that occurred in more than one virtual patient interview transcript was included in the list of frequent questions. The most frequent questions were rank-ordered based on how many times they occurred during interviews. Then the list of frequent questions was manually reviewed to identify and group alternate phrasings of the same question. For each set of questions, a primary phrasing was identified to represent the set of questions that will elicit the same information from the virtual patient. Finally, questions were grouped into different topics with the help of healthcare domain experts and then within each topic, the questions were ordered based on the average occurrence time in the interaction transcripts. This process is an example of processing that can be done to populate the virtual patient template.

Virtual patient templates can be specific to etiologies. That is, we could have a virtual cancer patient template that has the most frequent questions asked of a cancer patient and also a virtual stroke patient template for creating a patient that has recently suffered from a stroke. There could be some overlap of questions between both the cancer and stroke patient templates. In fact, based on our analysis of virtual patient interaction transcripts we identified 29 question-response pairs that were commonly asked of all patients irrespective of the etiology like name, age, ethnicity, medical history and social history questions. However, there are also a large set of questions that are specific to cancer or stroke patients and it is the capability of identifying and populating these questions in the respective templates that we consider an advantage of our methodology.

3.4 Step 4: Create virtual patients from template

Now that we have a virtual patient template with pre-populated questions, healthcare students can use it to create virtual patients. Filling in the responses for all the questions on the template will allow for students to create a robust initial version of their virtual patient. Once this initial version has been created, students can further improve their virtual patient's conversational corpus by adding in questions and responses that were not part of the patient template but are necessary information for their virtual patient.

3.5 Step 5: Improving patient template based on new virtual patient interactions

Once they have a satisfactory version of the virtual patient, the student can then share their virtual patient with their peers, the instructor or other friends and acquaintances to get feedback about the virtual patient created. Since the virtual patient created is a representation of the knowledge structure of the student, feedback will help the student learn and improve their knowledge about the etiology represented by the patient. By reviewing any additional content added to the patient created from the template, new questions as well as alternate phrasings for existing questions can be added back into the patient template to improve it. For example, the generic patient template originally has twenty other ways of eliciting the patient's name. During an interaction with a patient that was created using the template, a user could use a previously unknown phrasing for eliciting the name of the patient. We can now not only add it into the corpus for that patient, but also add it into the patient template to benefit all the future creators who will use that template to create virtual patients. Through this iterative approach of augmenting the virtual patient templates, we can improve the robustness of the virtual patients created using the patient templates.

4 EDUCATIONAL COURSE INTEGRATION

To evaluate the feasibility of our approach for creating robust and diverse virtual patient, we integrated virtual patient creation exercises into two healthcare education courses over the course of six years. Seven cohorts of students completed virtual patient creation exercises as part of these course integrations. The course integrations were completed at two institutions in the United States and New Zealand. 137 healthcare students participated in virtual patient creation exercises and 136 virtual patient corpuses were created as a result of the course integrations. During each of these course integrations, it was also observed whether healthcare students can improve their clinical interviewing and interpersonal skills by creating virtual patients. The focus of this paper is to highlight that the virtual patient creation process, in addition to being a valuable and effective learning experience, is also useful for creating robust and diverse pedagogical social agents necessary for training future healthcare students.

4.1 Course information and population

[University of Florida]: Five out of the seven total course integrations were completed at the University of Florida between 2011 and 2015. During these five years, the virtual human creation exercise was integrated into a health professions course for speech and language pathology students titled "Dysphagia Management" that was taught at the University of Florida. Dysphagia is a medical condition where the patient has difficulty swallowing food or liquids. The course was taught for four months between January and April of each year and the virtual patient creation exercise ran throughout the duration of the course. The virtual patient creation exercise was presented to the students as an extra credit option. The extra credit offered was 5 additional points on the final exam score for the students who successfully complete the virtual patient creation exercise. All the students who completed the virtual patient exercises as part of coursework over the five years were graduate students studying to become speech language pathologists. Majority of the students were either in the first or second semester of their graduate studies for a Master's in Speech Language Pathology. In the future, as speech language pathologists, these students will have to interview real patients, some of them suffering from dysphagia. Hence interviewing and interpersonal skills are very relevant to this population [25]. We had 141 students registered for the Dysphagia Management course at the University of Florida over the five years that the course integration was completed. 100 out of the 141 students participated in extra credit virtual patient creation exercises and created their own patients.

University of Auckland: The last two course integrations were conducted at the University of Auckland in New Zealand. The virtual human creation exercise was integrated into the final "Clinical Practicum" component of the second year of the two-year Masters of Speech-language Therapy Practice program. Students complete clinical practicum courses in each of their four semesters of the program during which they participate in field placements, clinical tutorials and complete clinically-focused assignments. During field placement, students would regularly be required to interview patients, their family and other healthcare professionals about their medical and social situation and their swallowing difficulties. The final Clinical Practicum course was taught for four months between July and October of each year and the virtual patient creation exercise ran throughout the duration of the course. The virtual patient creation was not assessed coursework, but students were encouraged to include their virtual patient creations, interviews and feedback in their final submitted clinical portfolios. All the students who completed the virtual patient exercises as part of coursework over the two years were postgraduate students studying to become speech-language therapists. We had 38 students registered for the Clinical Practicum course at the University of Auckland over the two years that the course integration was completed - 2015 and 2016. Table 1 below provides demographic information about the participants from the course integrations that were completed over all six years at both institutions. 92% of all students who participated in virtual patient exercises from both institutions were female. This gender ratio is representative of practicing speech pathologists in the real world - 95% of speech language pathologists registered in the United States are female [6].

Students who volunteered, created virtual patients using an online web application that we built based on our approach called the Virtual Patient Pipeline. As part of the virtual patient creation exercise, the students completed the following tasks:

(1) **Patient Template (2 hours)**: The student filled out a dysphagia patient template to create an initial version of their virtual patient. The dysphagia patient template used in this study was a form/wizard with 124 unique questions that all dysphagia patients are expected to answer. For each entry in the template, the questions were pre-populated, and the response was left blank for the student creator to fill in.
(2) **Interview the virtual patient (1 hours)**: The students were instructed to conduct at least two 20-minute interviews with their own patient in this step to improve their virtual patient and add any missing information.
(3) **Interview each other's patients and provide feedback (2 hours)**: The students interviewed each other's patients and provided feedback. Each student interviewed two virtual patients created by two other students from the class for at least ten minutes. The student filled out a feedback survey about each virtual patient he or she interviewed. At the

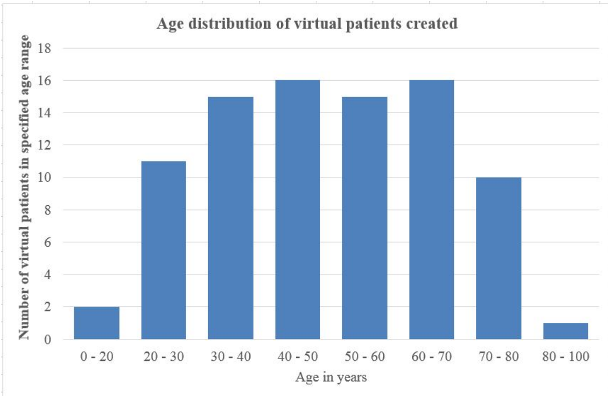

Figure 4: Age distribution of virtual patients created

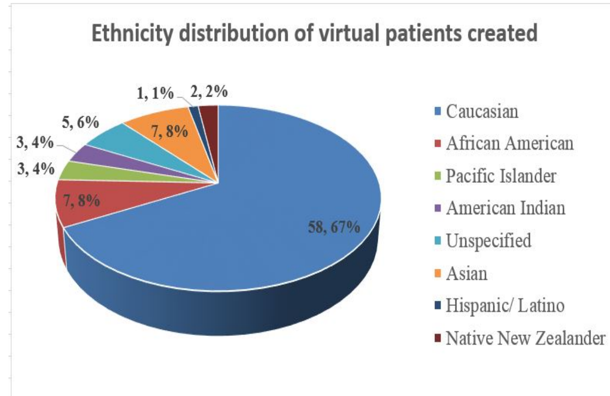

Figure 5: Race distribution of virtual patients created

end of the feedback phase, the student reviewed feedback provided about his or her patient by two of their classmates. Based on the feedback, students were encouraged to make changes to their virtual patient. The process of interviewing other's patients and getting feedback was double-blinded.

4.2 Virtual patients created

Conversational corpus information for the 136 virtual patients created as part of the course integrations are presented in Table 1 below.

4.3 Diversity of virtual patients

It is imperative that the virtual patients used for interpersonal skills training be diverse in terms of etiologies, gender, age and race portrayed. Previous research has shown how virtual patients of varying gender and race can elicit real world biases during interactions and also help with cultural competency skills [19] [21]. During our virtual patient creation exercises, only during the 2014 course integration (in which 50 virtual patients were created) students were instructed to create patients of a specific age, gender, race and etiology. During all the other six course integrations (86 patients created), students could choose their own age, gender, and ethnicity. Results from the age and race distributions of the virtual patients created are represented in Figures 4 and Figure 5 respectively and demonstrate that the virtual patients created were diverse with respect to age and race. In terms of gender, 52% of virtual patients created were female and 48% were male.

The etiology for the virtual patient could influence the choice of age, race and gender, for example, older patients are more likely to suffer from a stroke. However, it is important that the virtual patients created are diverse, so that students training with them can be trained to handle not only the common cases but also uncommon cases. To confirm that the diversity was not induced by etiology, during the 2015 course integration, all 11 participating students were asked to create virtual patients suffering from dysphagia due to a stroke. All the 11 virtual patients created had the same etiology but had diverse age (Mean = 51.36, SD = 13.67), gender (55% female, 45% male) and race (72% Caucasian, 18% African American and 10% unspecified).

5 EVALUATION OF VIRTUAL PATIENTS CREATED

In this section, we present results that reinforce the pedagogical usability and learning value of the virtual patients that were created. We only provide a sample of the evaluation results because the scope of this paper is limited to defining the methodology for social agent creation. We demonstrate that other healthcare students can learn clinical interviewing skills by interacting with the virtual patients that were created using our proposed methodology.

Results from our course integrations also demonstrate that in addition to facilitating the creation of robust and diverse virtual humans, the creation process also enabled students who created virtual patients to learn clinical interviewing and interpersonal skills during the creation process itself. A detailed report of these learning effects and results are reported in other publications [9, 11].

5.1 Robustness

As evidence of the robustness of the virtual patients created, the accuracy of the virtual patients during interactions with other students in Step 3 was measured and analyzed. The accuracy of a virtual patient interaction is defined by the percentage of the interviewer's questions that are responded to with accurate information during an interview. A virtual human expert manually reviewed transcripts of interactions and coded every question-response pair in each of the transcripts to calculate accuracy. Results from evaluating the accuracy of the seven virtual patients created during the first course integration in 2011 is presented in Table 2 below.

5.2 Clinical interviewing skills learning

To validate that the virtual patients created were indeed pedagogical tools that can be used in interviewing skills training exercises, we had a different cohort of eighteen speech therapist students (N = 18) from another university interview four virtual patients that were created by students as part of the 2011 and 2012 course integrations. Two of the four virtual patients were the most robust virtual patients created in 2011 (Vinny Devito and Marty Graw from Table 2 above) and the other two from 2012. There was a three-week interval between each virtual patient interview. A total of 72 (18 * 4) transcripts were generated with an average of 77.65

Table 1: Participant demographics and conversational corpus information from the course integrations

Year	Students registered	Student creators	Virtual patients created	Average Age	% Female	Avg. no. of Questions	Avg. no. of Responses	Creation Time per patient (hrs)
2011	31	31	7	24.7	88%	1193.2	370.0	3.8
2012	28	18	18	25.0	93%	1044.6	214.9	4.9
2013	29	15	15	23.2	93%	933.8	203.7	3.2
2014	26	25	50	24.2	96%	920.9	142.3	5.4
2015	27	11	11	24.5	89%	932.2	145.7	2.0
2015	18	18	16	25.8	89%	813.6	124.7	2.5
2016	20	20	19	26.0	95%	996.1	154.7	-
Total / Avg	**178**	**138**	**136**	**24.7**	92%	**976.3**	**193.7**	**3.6**

Table 2: Accuracy of virtual patients created during interactions with other healthcare students

Virtual Patient	Questions	Responses	Accuracy
Marty Graw	1238	362	77.83%
Vinny Devito	1358	465	72.84%
Jackie Dauer	1576	557	70.82%
Kahlua Lopez	837	302	69.07%
Johnny A Seed	1253	343	68.56%
John Smith	897	191	64.26%
Anne Animus	635	277	51.07%
Average	**1193**	**370**	**70.56%**

questions asked per transcript (SD = 48.51) and an average time of 39.05 minutes (SD = 23.51) per interview. The average response accuracy for the transcripts was 79.4% (SD = 9.95%).

5.2.1 *Metrics.*

For each virtual patient interviewed, there were critical pieces of information that the interviewer had to discover. These critical pieces of information were called discoveries. An example of a discovery is "*Swallowing problem started three months ago*". The discoveries for each virtual patient were chosen by dysphagia education experts depending on the etiology for that patient. Once a discovery list was made for a virtual patient, responses in the virtual patient's corpus were tagged with appropriate discoveries. Once the discoveries were tagged, the corpus was reviewed to make sure that each discovery had at least one tagged response and each tagged response had at least five questions that allow that discovery to be elicited. This ensured that eliciting the discovery was not affected by the corresponding response not having enough alternate phrasings. In this paper, we report on two metrics for measuring clinical interviewing skills - the percentage of discoveries made during each interview and the average number of questions per discovery. The percentage of discoveries is the ratio of total discoveries made by a student to the total number of discoveries available for that virtual patient and represents how much critical information the student elicited from the virtual patient during the interview. The number of questions per discovery was the total number of questions asked during an interview divided by the number of discoveries made during that interview. This is essentially an efficiency metric and provides us information on how efficiently students were able to elicit critical information from the virtual patient. The lower the value for this metric, better the efficiency at eliciting critical information.

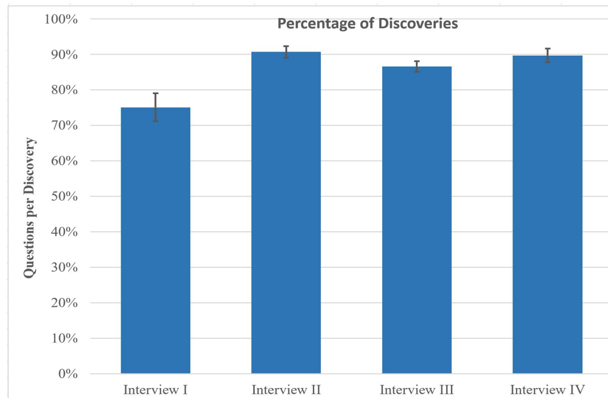

Figure 6: Percentage of discoveries made for the four virtual patient interviews

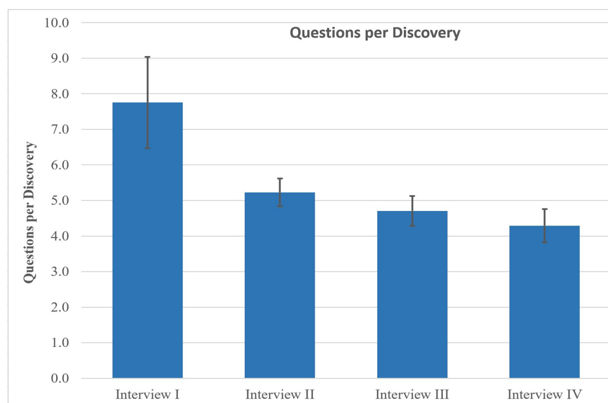

Figure 7: Number of questions per discovery for the four virtual patient interviews

5.2.2 ***Results***.

Participants were able to elicit significantly higher percentage of discoveries over the course of the four interviews: The percentage of discoveries elicited for the four interviews is plotted in Figure 6 above. We performed a paired samples t-test comparing the percentage of discoveries made at each of the four patient interviews. There was a significant difference between the percentage of discoveries made between the first interview (Mean = 75.1%, SD = 16.8%) and the final interview (Mean = 89.7%, SD = 8.2%), t (17) = -3.50, $p < 0.005$. There was a significant difference between the percentage of discoveries made between the first interview (Mean = 75.1%, SD = 16.8%) and the second interview (Mean = 90.7%, SD = 6.9%), t (17) = -3.98, $p < 0.001$ and a significant difference between the percentage of discoveries made between the first interview (Mean = 75.1%, SD = 16.8%) and the third interview (Mean = 86.6%, SD = 6.4%), t (17) = -2.64, $p < 0.01$. There was also a significant difference between the percentage of discoveries made between the second interview (Mean = 90.7%, SD = 6.9%) and the third interview (Mean = 86.6%, SD = 6.4%), t (17) = 2.22, $p < 0.05$. There were no other significant differences observed between any of the other comparisons. The results indicate that students were able to improve the amount of critical information elicited from the virtual patient by interviewing virtual patients created by other students.

Participants were able to significantly reduce the number of questions per discovery over the course of the four interviews: The number of questions per discovery elicited for the four interviews is plotted in Figure 7 above. We performed a paired samples t-test comparing the number of questions per discovery at each of the four patient interviews. There was a significant difference between the number of questions per discovery between the first interview (Mean = 7.76, SD = 5.5) and the final interview (Mean = 4.29, SD = 2.0), t (17) = 2.62, $p < 0.05$. There was a significant difference between the number of questions per discovery between the first interview (Mean = 7.76, SD = 5.5) and the third interview (Mean = 4.71, SD = 1.8), t (17) = 2.42, $p < 0.05$. There was also a significant difference between the number of questions per discovery between the second interview (Mean = 5.23, SD = 1.7) and the final (Mean = 4.29, SD = 2.0), t (17) = 2.05, $p < 0.05$. There were no other significant differences observed between any of the other comparisons. The results indicate that students were able to improve their interviewing efficiency represented by asking lesser number of questions to elicit a discovery by interviewing virtual patients created by other students.

6 CONCLUSION

In this paper, we have introduced a novel approach for scalable social agent creation by having healthcare students create virtual patient pedagogical agents as part of an interpersonal skills training exercise. Students can create robust and diverse virtual patients by reusing information from previous student-created virtual patients and interactions with those virtual patients. We have outlined this approach and provided data from seven course integrations to demonstrate that healthcare students are able to create educational artifacts through this process. In the future, by deploying this process in more healthcare education courses, we hope to build a library of diverse and robust virtual patients that can be used for learning and research purposes.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Andrea Kleinsmith, Stephanie Carnell and Aarthi Madhavan for their advice and assistance with conducting the research reported. This work was made possible by a Veterans Administration Rehabilitation Research and Development Grant (Grant ID: B0339-R).

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