Development of Interactive Patient Simulator Using Emerging Visualization Tools for Medical Training

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ABSTRACT

Medical students and trainee doctors are required to be exposed to various aspects of medical sciences for hand-on and realistic training. Over the years, such trainings have been dependent on actual patient and medical cases. This does provide a realistic understanding and assessment opportunity for the trainee doctors and medical students, but it might not be possible to expose them to every type of medical complexity. Technological development can help in overcoming this challenge and medical cases can be simulated using visualization tools to provide a game like challenging environment for encompassing both knowledge and motor skills for doctors. Not only this, but trainees' performances can be better evaluated through such simulated visualization applications. In alignment with the concept, "Interactive Patient Simulator (IPS)" has been developed by the NED university Virtual Reality Center to assist in education delivery and learning for medical science students and trainee doctors. The Interactive Patient Simulator is a medical tool for training and assessing trainees and doctors for clinical scenarios in emergency room environment. It involves assessing the patient's medical condition, performing some medical procedures for diagnostic purposes and finally making a differential diagnosis on the basis of which a trainee performance report is generated.

Keywords: Clinical simulations, cognitive, clinical interventions, diagnosis, patient simulator, pshychomotor, physical exam.

INTRODUCTION

Professional education learning and delivery revolves around three learning domains for effective skill development. These include cognitive learning (related to mind and knowledge), psychomotor learning (motor, hands-on, practical skills), and affective learning (feelings, behavior skills). The training of medical students and trainee doctors typically depend on either in-class theory-based case studies and, seldom, through exposure to an actual patient. Both of these are realistic methods, but opportunities may not exist to explore and learn various types of medical complexities.

Moreover, for medical science students, only in-class theoretical explanation cannot be enough, and often non-availability of medical cases coupled with strict bio-ethics protocols can result in more cognitive and less effective psychomotor learning experience. Hence, fresh medical graduates usually spend many years to acquire the sufficient clinical skills, for their preparation (Kapoor et. al. 2014). The medical field has undergone major changes worldwide. The new standards requires that the fresh graduates have acquisition of more clinical skills rather than simply having the theoretical knowledge. Past studies shows that most of the medical graduates have completed their educational programs with more theoretical knowledge, but lesser or less effective clinical skills (Melús-Palazón et. al. 2012).

Developments in advanced simulation technologies integrated with concepts of gaming has enabled creation of learning assistance tools. These simulations can help in delivering combination of knowledge, motor, and decision-making skills to trainees and also allow to evaluate them through performance-based assessment.

Thus, to bridge the gap a medical or clinical simulation can play pivotal role for teaching delivery and learning. "Studies have shown that medical simulation plays an effective role to teach students the essential clinical information, procedural skills." (Al-Elq 2010). There is significant influence of clinical simulations in health care education. Simulation sessions lead to important skills such as; teamwork, communication, cooperation, and professional skills (Ciorap et. al. 2014). Human patient simulators focus on providing skills including decision-making, teamwork, and crisis management. Although, the prime use of patient simulators is for educational research and practice, but they can also be used for many other applications related to cognitive engineering and human factors research (Segall 2007). Hence, training of medical staff is crucial, and, especially the lack of opportunities for training using real live patients in the context of pandemic has further highlighted the curiosity towards virtual patients (Bálint et. al. 2021).

With the aforementioned context, NED University VR center has developed "Interactive Patient Simulator (IPS)" to facilitate knowledge and skills delivery. The IPS is a learning and assessment tool for medical students and trainee doctors in an emergency room environment. The assessments include; history taking through dialogues, physical diagnosis, monitoring, testing and finally reporting the user performance. The report determines the accuracy of the assessment made and reflects the doctor's efforts. The simulator is designed using advanced asset modeling tools, scene modeling tools and programming to provide interactive learning experience.

OBJECTIVES

The objective of this project was to develop a case based "interactive patient simulator." This was to showcase the capability of emerging computer-based visualization tools for clinical simulations in health care education. Such simulators could be much more effective for in-class and on-job cognitive as well as psychomotor learning to ensure better clinical decision-making skills without compromise of bio-ethics protocols.

METHODOLOGY

The methodology adopted for the development of interactive patient simulator had following steps.

Literature Review: Detailed literature review was conducted in order to collect case information. The selected case scenario was of "Difficulty breathing, wheezing" of 41-year-old women who has suffered with breathlessness in history a few years ago. When the condition re-occurred, she had to go to emergency room, where she will be subjected to various aspects of clinical assessment by the doctor. The case information was collected from commercial data resources and was conformed with a local doctor for better understanding and hence development of IPS.

Story Boarding and Scene: In second stage of the development, storyboard was prepared to include 3 major scenes.

1. Initial Scene: This scene is meant for the authorization of the user. A predefined username and password have to be entered in order to advance to the assessment stage. Entering invalid credentials displays an error message prompting the user to type accurate credentials in the next attempt.
2. Assessment: The trainee/doctor has a number of options at his/her disposal to assess the patient, which includes; dialogues for patient history taking, physical examination, monitoring, tests, call and interventions.

3. Reporting: This scene was included to display the performance of trainee for each aspect of assessment individually, and also integrated as a whole simulation process.

Asset Collection and Modeling: After the storyboarding, assets including patient avatar, medical equipment, emergency room environment and other ancillaries were collected. Moreover, the assets were modified using modeling software (Blender) to accommodate the requirement of the application. All these assets were then integrated into Unity 3D platform for development of various scenes as described earlier. Camera angles were set for better display.

Programming for Interaction: After integration of the assets, detailed C language programming was done in order to integrate controls of different menus, back ground emergency room sounds, verbal response of the patient to each dialogue-based question, sound effects of physical diagnoses, appearance of physical diagnostic tools at various location of the patient, test reports appearance and mobility, performance reports graphs generation etc. Furthermore, the IPS has three time-based challenges i.e., 20 mins., 30 mins., and 40 mins. This challenge is programmed to increase or decrease the level of complexity for the trainees, according to their level of learning. All these integrations were done in order to ensure realistic simulation environment for the user and making it an effective learning experience.

RESULT

The aforementioned methodology resulted in development of interactive patient simulators with capabilities of assessment and performance reporting.

ASSESSMENT

Following is the explanation of different types of assessment that can be performed with the IPS.

1. Dialogue: The patient is inquired about her health condition through a variety of questions. This is performed by first clicking on the Dialogue button, then on one of the subsequent five categories, and finally on the questions in each of those categories, as illustrated in the pictures below. It is dependent on the trainee/doctor to ask appropriate number of questions, since not all of them have an equal weightage. The patient responses are also displayed on dialogue boxes for respective questions. Same questions cannot be asked twice in the same go, since they are rendered non-interactive once they have been asked. The screens can be dragged anywhere if needed.
2. Physical Examination: The physical exam initiates the ABCDE assessment. It consists of the procedures that have to be performed on the patient to characterize and monitor findings on her admission. The procedures have to be performed through various menus that appear on clicking the procedure options. The patient responds invariably to each individual procedure. The responses of such procedures are either sound cues, for instance heart beating, inhaling and exhaling or bowel sounds, etc. The menus can be dragged for maximum screen real-estate.
3. Monitoring: The patient vital signs are monitored closely through this option. They are enabled by pressing the options once and then toggling the checkboxes. The options are rendered non-interactive once pressed for score calculation.
4. Tests: This option mandates that tests be performed on the patient to further diagnose the patient. For this reason, blood and sputum samples are collected initially and a variety of tests are performed on them to examine the patient's condition. Furthermore, electrophysiology and imaging tests can be performed and viewed in their respective submenus. The test results of multiple categories can be viewed simultaneously and can be zoomed.
5. Medication: The patient is administered appropriate medications through the Medication option.

6. Interventions: High flow mask and a catheter can be administered to the patient through the Interventions option. This is a two-step process involving the clicking of the respective options to enable the checkboxes, and then toggling the checkboxes for administering the interventions.
7. Call: A request to shift the patient to the ICU can be made through the call option.

Performance Reporting

The trainee/doctor's score is tracked through checking the options clicked in the various submenus during the patient's assessment. Each option has one of the following priorities:

1. 1st Priority - mandatory items to solve the case successfully.
2. 2nd Priority - optional items that are considered adequate, but are not essential.
3. Not a Priority - unnecessary items that are considered inadequate or a waste of time.

The overall score is then calculated based on the scores obtained in the various categories. The details of the score can be viewed in the Report scene. The report displays the scores obtained in each of the categories. The score is calculated taking into account the priorities of each option chosen by the trainee/doctor during the assessment. In addition, overall score can also be viewed. Following Figures provide some snapshots of the developed *Interactive Patient Simulator*.

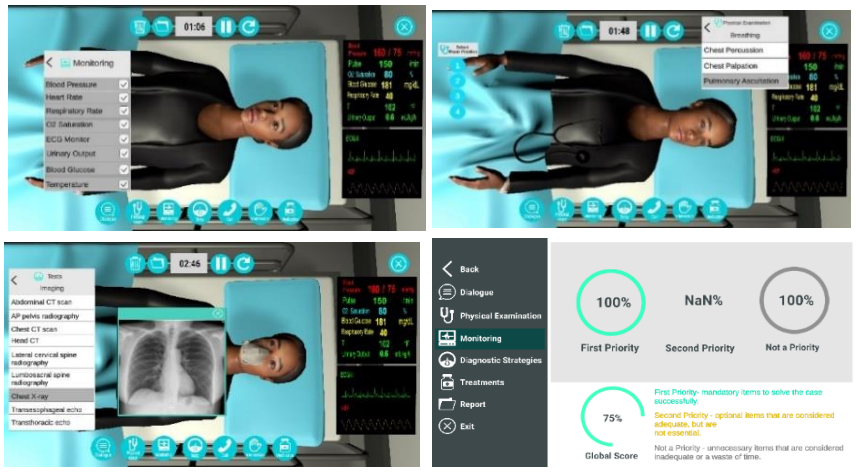

Figure 1. Snapshots of IPS – Top Left – Monitoring; Top Right – Physical Examination; Bottom Left – Tests; Bottom Right Reporting

CONCLUSION

The IPS was developed for purpose of facilitating teaching and learning process. So far, the selected experts, who have been exposed to this product on trial basis, have shown qualitative agreement to effectiveness of the same in medical education. The visualization quality of the developed IPS can entrust more learning willingness among the trainees, as per different experts who have been part of the trails. Furthermore, quantitative assessment of the effectiveness will also be established through data collection and analysis form the actual users over a longer period of time so statistical effectiveness can be established as well as learning curve for future developments could be ensured. The center is working on developing simulator with cost effective Virtual Reality as well and certain prototypes have been developed. The author has also concluded that more cases will be developed and ultimately, visualization will need to be integrated with artificial intelligence in order to make this tool dynamic, challenging, and effective.

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