

## NURSING PAIN ASSESSMENT & MANAGEMENT: A 3D INTERACTIVE SIMULATION

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In this design case, a team developed a 3D interactive simulation for nursing students and professional nurses to train and practice pain assessment and management procedures. In the simulation environment, the trainees interact with three emotionally expressive animated patients. The three patients vary in their ethnicity, age, and emotion intensity. Successful completion of the scenario requires that the trainee perform a series of pain assessment and management tasks. The trainee is evaluated on the efficiency and appropriate sequencing of the tasks.

The purpose of this paper is to describe the decisions made regarding the type of virtual patients used, the clickable objects, the pain assessment interview protocol, the visual representations in the simulation and the web portal. The paper also provides insight into the processes and steps taken during the design and development phases of this 3D interactive simulation including: the tasks analyses, motion capture, validation of the animations in the simulation, programming, and other tasks.

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### INTRODUCTION

The purpose of this paper is to describe the process of designing and developing a 3D interactive simulation. This simulation was intended for research purposes, to understand the differences in pain assessment and management practices between novice nursing students and professional nurses when interacting with a 3D interactive simulation. The design and development goals for the project included:

#### FRONT-END (USER INTERFACE)

- To design and develop a 3D interactive interface with ease of use and a visually appealing look.
- To have realistic virtual patients with human-like movement, voices, and facial expressions of emotion.
- To create a realistic hospital environment, including a detailed patient room and hospital hallway.
- To provide a realistic nursing scenario, including adequate nursing documentation and patient medical records.
- To re-create a realistic interaction between the nurse (trainee) and the virtual patient, including credible nurse-patient dialogue.

#### BACK-END (PROGRAMMING)

- To program an interactive point-and-click system for the objects in the patient room.
- To program an interactive interview between the trainee and virtual patient.
- To program the virtual patient with emotion-like animations.

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- To program virtual movement of the trainee in the patient room and between patient rooms.
- To store detailed logs (actions and points obtained for each action) of each trainee (research participant), reviewable by the project manager.

Most of the design and development goals (front-end and back-end) were established during the initial planning meetings of the design team. However, a few goals were established based on project execution time, programming skills, and availability of resources.

The design processes described in this paper include descriptions of the design team, design procedures, trainees (research participants), tasks analysis, performance measures, virtual patients, and other design decisions. The development processes described in this paper include descriptions of the motion capture process, the 3D environment development, and the validation study.

Ultimately, we hope to provide a clear description of the judgments and decisions made and how the design process unfolded from the design team's point of view. By presenting this simulation design case, we hope to participate in the ongoing dialogue among those who design for learning and to contribute to the literature from which other designers draw knowledge and guidance.

## DESIGN TEAM

This project was the effort of a multi-disciplinary academic team. The design and development team for this simulation project included: a visualization specialist, a computer programmer, an electrical & computer engineering research faculty member, an instructional design faculty member, and an instructional designer. The instructional designer was the project manager.

All members of the team worked in the same higher education institution. However, the visualization specialist, the computer programmer and the electrical & computer engineering research faculty member work specifically for a university-wide multidisciplinary research center that emphasizes modeling, simulation and visualization research, development, and education.

## DESCRIPTION OF THE SIMULATION

### Simulation Scenario

The scenario of the simulation transpires during the day shift in an emergency department of a local hospital. The nurse (trainee) provides care to Jose Rodriguez, Lin Chan, and Arthur Smith, patients who came to the facility after their golf cart flipped over earlier in the day. All three patients are alert and orientated to person, place, and time.

Dr. Scott, the physician, has already assessed the patients and left medical orders. This is the nurse's first encounter with the patients. All three patients are complaining of abdominal pain and adopting positions of discomfort. They also have some contusions, scrapes on their arms, bruising in the forehead, and black and blue marks on their shoulders from the seatbelt. In the scenario description, learners are notified that the lab work is complete and available via the electronic medical record for each patient.

### Training Objectives

The need to design and develop this simulation was first established by two members of the design team, the instructional designer and the instructional design faculty member, and a subject matter expert (SME) in nursing. The two members of the design team and the SME agreed that this simulation would provide the groundwork for other projects with similar context, within the same higher education institution, that required training related nursing/medical simulations. In nursing and medical education, simulations provide students with an opportunity to work through situations they may not experience during their clinical rotations (Curtin & Dupuis, 2008). Based on this decision, the instructional designers reached out to other faculty members to form the design team.

One of the first tasks performed by the instructional designer, once the design team and the need for the simulation were established, was to determine the training objectives of this specific simulation. The following are the training objectives identified by the instructional designer:

After engaging with this 3D interactive simulation, trainees should be able to:

- Confirm a patient's identity
- Apply proper nursing actions to initiate care of a patient, evaluate a patient (including vital signs and pain assessment)
- Determine the nursing care for a patient based on assessed patient condition (including reported and observed pain)
- Implement appropriate and safe pain management care of a patient.

Pain management for patients in the emergency department is accomplished by ensuring that the patient has recovered, is oriented, has stable vital signs, and shows no evidence of complications (Ackley & Ladwig, 2011; Herr, Bjoro, Steffensmeier, & Rakel, 2006). Ideally, the nurse (trainee) should intervene at the patient's first report of pain to control the problem rather than wait for it to progress (Ackley & Ladwig, 2011; Herr et al., 2006).



## Patients' Descriptions

In addition to the training objectives, another important preliminary task was the creation of the patient descriptions. The instructional designer established the initial patient descriptions. These descriptions included the same age, hobbies, and ethnicity for the three patients. A SME, specifically a nursing faculty member, revised the descriptions to validate the adequacy (i.e., age, ethnicity, social habits) of the virtual patients to the general population that on an everyday basis visits a hospital emergency department. This revision led to a more diverse group of patients from different age groups, ethnicity and social background. The patients in this simulation scenario are: Jose Rodriguez, Lin Chan, and Arthur Smith. Each patient is described below.

**JOSE RODRIGUEZ** is a middle age man. He is described to the trainee as a 45-year-old Hispanic male. He weighs 190 pounds. His medical record states that he is allergic to bee stings and that he enjoys playing golf and working in his yard. His past medical record states that he gets the flu shot every year and that he walks 3 to 4 miles every day. In the 3D simulation, Jose reports a pain level of 9. However, the emotion pain intensity portrayed by Jose Rodriguez is 3.

**LIN CHAN** is described to the trainee as a 30-year-old Asian American male. He weighs approximately 120 pounds. In his medical record it is stated that he is allergic to Aspirin. In the simulation Lin reported having a pain level of 9. However, the emotional pain intensity portrayed by Lin is 6.

The last patient, **ARTHUR SMITH**, is described to the trainee as a 60-year-old white male. He weighs 145 pounds. He is allergic to Penicillin. In the simulation he reports a pain level of 9. The emotional pain intensity portrayed by Arthur is 9.

In the simulation, the emotion intensity is equivalent to the observed conduct expected for specific pain scores as measured by the Visual Analog Scale (Atkinson, Chesters, & Heinz, 2009).

Jose Rodriguez portrayed a neutral expression and spoke normally. As stated, Jose has low emotion intensity (level = 3). Lin Chan was very protective of the affected area, had less movement, and complained of pain. Lin has moderate emotion intensity (level = 6). Arthur Smith was restless, unsettled, complained about lots of pain, and cried inconsolably. Arthur has high emotion intensity (level = 9).

Although the virtual patients report a pain level in the simulation, the trainee is encouraged to analyze the subjective information (e.g., patient medical record), the vital signs data (e.g., blood pressure, heart rate, respiratory rate, temperature), the responses from the pain assessment interview and the emotion intensity of the patient to determine the best intervention method (e.g., non-medication or medication intervention).

## DESIGN PROCESS

### Design Procedure

During the first three months of the project, the project manager and faculty members met regularly, on a bi-monthly basis, to brainstorm and document initial ideas for the simulation flow and decision-making tree. For training, simulations engage the participants in different types of actions and decision-making processes (Gredler, 1994; Kriz, 2003; Martin, 2000). These initial meetings also served to establish a timeline for the instructional design processes and resources available for the project (Figure 1). In subsequent meetings, all team members met to discuss the documentation, design procedures, and development procedures. Once the development process started, during the last six months of the project, the project manager met weekly with the visualization specialist and the computer programmer to review initial prototypes of the simulation environment and to verify the accuracy of the programmed interactivity in the simulation.

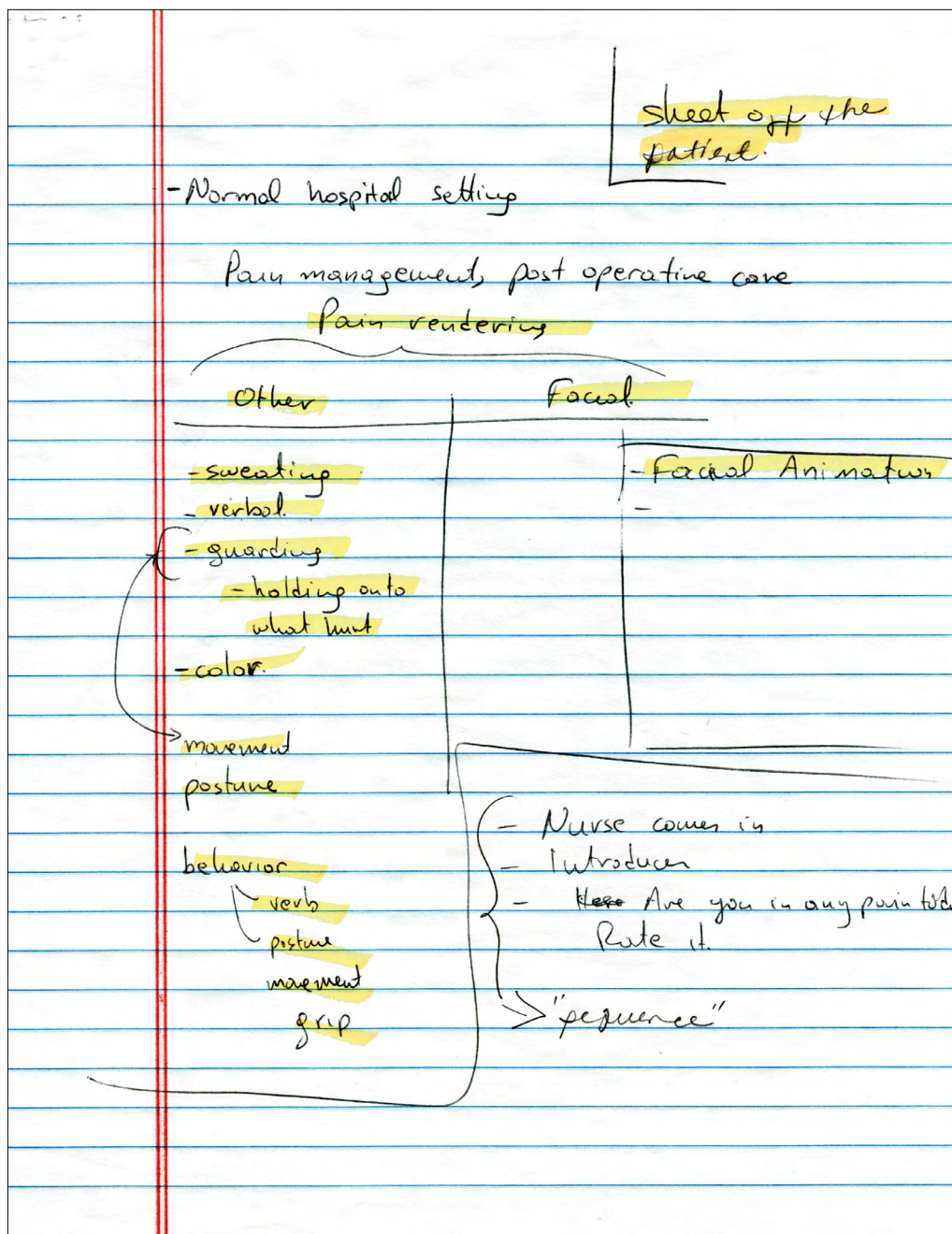
The majority of the communication between the team members occurred during face-to-face meetings. In addition, the team members used email and Dropbox for communication and file exchanges.

This simulation project was completed in one year. As this project was an unfunded project, the majority of the resources used for the design and development of the simulation were those available in the institution (e.g., software, equipment, and hardware).

### Descriptions of the Trainees

One of the team's initial decisions was the definition of the target audience. This decision was linked to the research objectives of the project, which included a comparison between novices versus professionals. There is evidence that simulations can assess novice versus expert differences in nursing and medical simulation performance (Anderson, Aylor, & Leonard, 2008). To properly determine who would be classified as a novice nurse and who would be best classified as a professional nurse in pain assessment and management, the project manager and the instructional design faculty member consulted with a nursing faculty member SME.

As recommended by the SME, the target population to be classified as novice nurses are undergraduate nursing students who have taken basic nursing classes in which pain assessment and management is a topic covered in the class. Those undergraduate nursing students include post-licensure juniors and seniors in a bachelors of science in nursing program. As explained by the SME, these students are farther in their program and aware of the skills and procedures needed to correctly assess and manage pain.



**FIGURE 1.** Design team meeting notes.

In consultation with the SME, a nurse with at least 3 year of experience in a clinical environment has the required knowledge to properly conduct pain assessment and management. Therefore, the team identified professional nurses as those with a minimum of three years of experience in nursing.

With the help of the SME, the project manager identified three universities in the Hampton Roads area from which novice nurses could be recruited: Old Dominion University, Norfolk State University, and Hampton University. The SME also recommended recruiting professional nurses from local

hospitals, clinics, and school districts.

### Task Analysis

Another important step in the design process of this 3D simulation was the initial investigation of the pain assessment and management nursing practice. For the team, including the project manager, this was a challenging step. We had very little knowledge of the required pain assessment and management procedures from a nurse's perspective. Although an initial review of the literature conducted by the project manager yielded great resources on the inadequacy of pain assessment and management practice and knowledge, the team had not yet identified the task required to complete the pain assessment and management task correctly.

It was suggested in a meeting with the SME that I, the instructional designer/project manager, should research the nursing literature for evidence-based nursing practices. The review of the literature was a productive effort, with a significant number of resources available, including a pain assessment procedures list, recommendations based on research and research

based on different demographics, age, and gender. However, the resources showed that nurses do not have a one formal pain assessment and management procedure. Instead, there are recommended sequencing and specific tasks that should be considered when conducting pain assessment and management procedures. In order to validate the results of the evidence-based research, a meeting with the SME was conducted to interview her on the processes followed in her nursing practice to properly deal with the patient's pain.

### *Critical Incident Method*

In anticipation of the meeting with the SME, the instructional designer made a decision to follow the critical incident method task analysis for the interview. The critical incident method helps instructional designers identify the critical elements of the task by prioritizing the behaviors that are vital to the job. This technique collects reports or descriptions of excellent performances that are exhibited by the target population (Militello & Crandall, 1999).

The SME for the critical incident method was an nursing faculty member with practical and academic experience with pain management nursing practices. The interview format was a structured interview, for which the instructional designer prepared a list of questions before the interview. During the interview, the instructional designers asked the SME to describe effective procedures that nurses should follow in the emergency department to assess and control pain. Using the answers provided by the SME, the instructional designers created a list of 18 procedures for nursing pain practices. Based on this initial set of competencies, the instructional designers condensed the competencies into six overall training objectives.

To understand which of the nursing pain practices identified by the SME were essential to the task, the instructional designer also conducted a criticality analysis. In other words, the instructional designer listed the procedures and the SME was asked to rate the level of importance of each of the statements. The criticality analysis is an important part of the process because it helps determine which procedures are worth training focus (Militello & Crandall, 1999).

The last step in critical incident method is called "organize or arrange the competency statements" (Militello & Crandall, 1999, p.185). During this step the SME arranged the competencies for nursing pain assessment and management under different sets of headings. Each heading represented a sequence in which nursing procedures were performed (e.g., initial tasks and subjective documentation, vital signs data collection, assessment interview, non-medication interventions, medication interventions).

### *Critical Decision Method*

In order to obtain information on specific behaviors regarding pain management nursing practices with emotionally distraught individuals, the instructional designer conducted a critical decision method task analysis. The critical decision method is a technique for learning from specific non-routine events that challenges a person's expertise (Militello & Crandall, 1999). The critical decision method employs a semi-structured interview format with specific probes to elicit goals, options, cues, contextual elements, and situation assessment factors specific to particular decisions (Militello & Crandall, 1999).

As part of the initial critical decision method interview, the instructional designer prompted the SME to recall a nursing event in which the patient was an emotionally distraught individual. The intention was to help the SME identify a difficult case where differences between the decisions of an expert or novice might be expected (Militello & Crandall, 1999). As the SME "walked through" the incident, the instructional designer documented the SME's input. To verify the accuracy of the documentation, the instructional designer re-told the story to the SME.

As part of the critical decision method the SME re-tells the story a second and third time. The second time the expert and the instructional designer pay close attention to the timeline of the events (Militello & Crandall, 1999). For example, the SME described that emotionally distraught individuals might reject pain medication. Therefore, it is better to provide non-medication interventions (e.g., comfort measures, repositioning the patient, encourage deep breathing) first. On the third telling, the SME re-tells the story with special attention to salient cues, the nature of the cues, expectations of how the incident might have evolved, and other context-specific account of the incident (Militello & Crandall, 1999). The cues that were prominent for this specific scenario of nursing practices and emotionally distraught patients are the role, reactions, and dialogues with family members.

Since the interactive nursing simulation was also intended to find differences in performance between novice and experienced nurses, the last procedure of the critical decision method was of great importance to this project. The last procedure focused on the "what if" strategy (Militello & Crandall, 1999). During this part of the process the instructional designers asked the SME to speculate on what would happen differently if the nurses were novices. The SME provided insight into nursing-specific expertise practices.

### **Clickable Objects**

Based on the pain assessment and management critical path established by the task analysis methods (critical incident and critical decision method), the instructional designer, visualization specialist, and programmers met to determine the best way in which the nursing procedures could be translated into simulated actions in the 3D interactive environment. During this meeting the members of the team decided that to properly measure the pain assessment and management activities in an interactive manner, objects related to the actions would be selected as "clickable" objects in the simulation environment. For example, the sink was selected as a clickable object for "washing hands." Learners would click on the sink and a pop-up window opened with the question "Do you want to wash your hands?" Learners have the option of selecting "Yes" or "Cancel." After selecting "Yes," an image of a person washing their hands appears in

the pop-up window and the message “You have successfully washed your hands.” Ideally, the learners using a simulated environment are able to experience the function of a particular role, including the decisions and consequences encountered when playing that role (Chua, 2005; Martin, 2000). In total, the team matched eighteen clickable objects, including: pain poster, thermometer, stethoscope, and scale.

Some of the objects related to the procedures identified by the SME in the task analysis and some were objects that did not relate to the pain assessment and management task (e.g., phone, room chairs, weight scale). The team members agreed that some clickable items should not be related to the pain assessment and management task, to avoid the case where the trainees click on all of the items to collect all of the points. Instead, by having objects that did not relate to the task, the learners would carefully select the objects on which they would click. This type of simulation-based training improves familiarization with medications instruments and medical equipment that enhances learners’ performance (Anderson et al., 2008).

Another concern that the team members had regarding the clickable objects was that the learners would not know which objects were clickable and which were not. The team had to decide to either highlight the clickable objects in the simulation environment using a “hot spot” marking or to provide some guidance to the learners before their interaction with the simulation environment.

The instructional design faculty member suggested providing a Simulation Objects Handout to the learners before and during the interaction with the simulation environments (Appendix A). The instructional design faculty member stated “before the interaction, trainees could review the handout to familiarize themselves with the interactive objects. During the interaction, trainees could refer to the handout to recall which clickable critical path objects are available in the simulation.” All team members agreed that having a handout would be a good way to provide guidance to the trainees. Additionally, this type of reference for the trainees to identify the clickable objects would not increase the programming time of the simulation project.

### **Pain Assessment Interview Protocol**

In addition to the clickable objects, trainees would conduct a pain assessment interview with the virtual patient when assessing the virtual patient. This task was identified by the SME during the meeting with the instructional designers. The SME explained that during their visit with the patient, the trainee should complete a pain assessment interview that consisted of seven important questions.

In order to correctly translate the pain assessment interview actions to the simulation environment, the instructional designer, the programmer, and the visualization specialist

discussed the best communication possibilities between the patient and the trainee given the resources available and the time constraints. The team agreed that the best method was to provide a textual representation of the interview questions on the simulation screen as a representation of the communication from the trainee. On the other hand, the patient would communicate with trainee using voice (i.e., audio). To properly assess the pain assessment interview skills of the trainee, the team decided that the trainee would be prompted to select one of three narrative choices for each interaction. The instructional designer, using evidence-based nursing practice literature related to pain assessment and management practice, scripted the narrative choices.

One of the narrative choices represents a correct pain assessment interview question to help assess the pain of the patient. If the trainee chooses this narrative choice, they receive two points towards their performance score. Another narrative choice represents a general medical assessment question; however it is not an interview question specific to pain assessment. If the trainee chooses this option, they receive one point. Lastly, one of the narrative options represents an irrelevant interview question. If the trainee chooses this option, they receive zero points.

The narrative choices that the trainee selects also modify the type of emotional outcome of the patient. If the trainee chooses the correct pain assessment interview questions, the patient provides a very cooperative and useful response to the trainee; whereas, if the trainee chooses the irrelevant interview question, the patient will act very stubborn and provide useless responses.

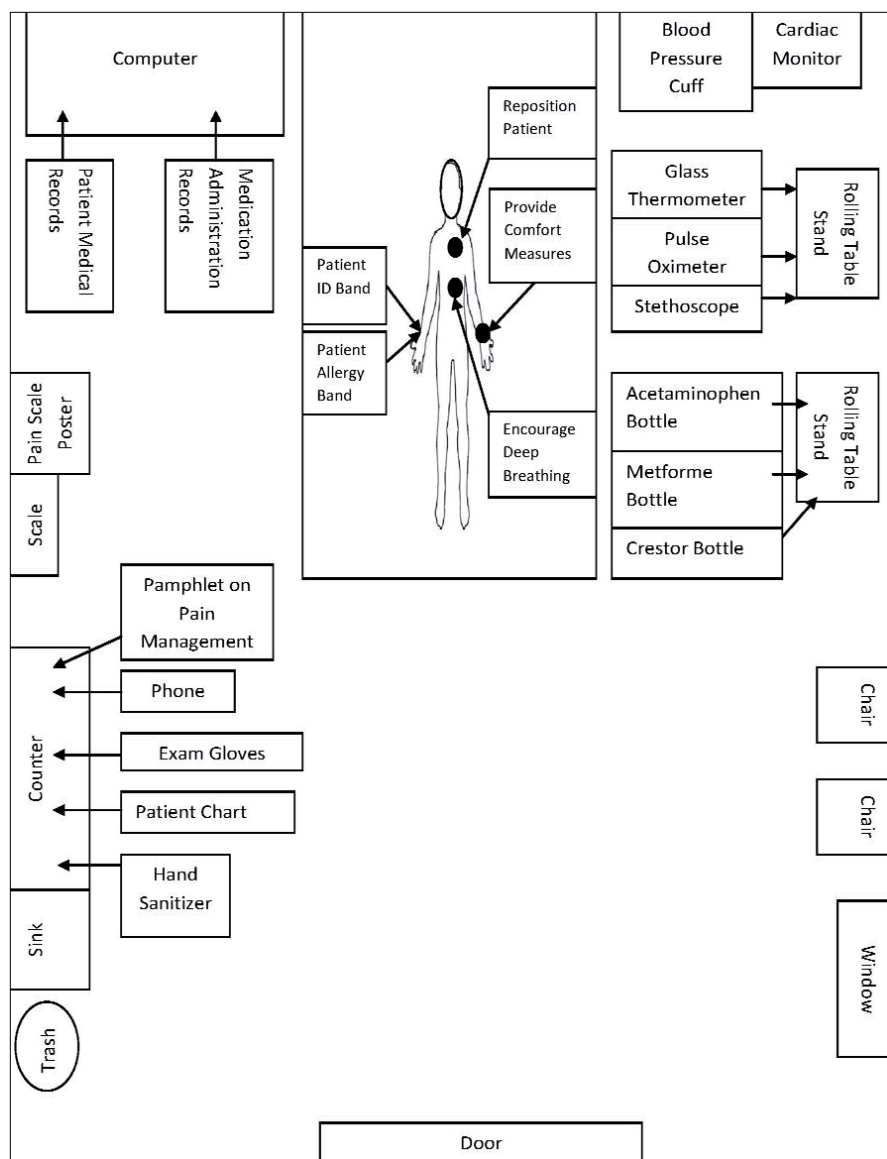
### **Visual Representation and Web Portal**

After the performance measures were established—the pain assessment procedure and interview—the team met to discuss decisions related to the visual representations of the emergency department and the external web portal. These decisions would help the visualization specialist with the initial development of the 3D simulation environment.

In regards to the simulated hospital locations, the team established that the simulation would start with the trainee standing in an emergency department hallway with easy access to the patients’ rooms. The rationale behind this decision was to eliminate or reduce navigation within the simulated hospital locations. As a result, the trainee would not have to learn navigation controls (i.e., keyboard arrows). From the hallway of the emergency department, the trainee can view the doors to the patients’ rooms, each marked with the patient name. To navigate into the room, the trainee can click on the door of the patient room and they are automatically transported inside the patient’s room.

Another reason that the team established the initial location of the trainee as they “enter” the simulated hospital





**FIGURE 2.** Patient's room (bird's eye view).

environment was the randomization of patient order for research purposes. One of the research elements included random order of patient visits. In some cases, the trainees would visit Arthur Smith first, in others cases they would be require to visit Lin Chan first or they could also start their patient visits with Jose Rodriguez. The randomization was not programmed into the simulation; instead, the research staff would manage it during the data collection phase.

To develop a realistic patient room, the instructional designer used the Internet to view and investigate layouts of patient rooms in the emergency department. Based on the information collected from images reviewed, the instructional designer created a mock-up with a bird's eye view of the patient room to share with the visualization specialist (Figure 2).

Another decision the team made regarded the viewpoint of the trainee within the simulation environment. The team agreed that in order to create a realistic experience for the trainees, it would be ideal for them to have a first person viewpoint. This included a 360-degree horizontal camera angle and 90-degree (up and down) camera angles. In this manner, the trainees would see the tasks as they experience them in real life.

To provide background on the simulation scenario, objectives, and instructions, the team determined that it would be best to create an external web portal with all of the initial information needed by the trainees before interacting with the 3D simulation environment. Initially, the team discussed the inclusion of tabs in the simulation interface that would expand when if selected; however, this option would require additional simulation interface design, programming time, and trainee simulation orientation. The web portal software, WordPress, provided a quick and easy interface in which the instructional designer could add, edit, publish and access content via the Internet. Additionally, the web portal via WordPress would be accessible to the trainees with an Internet browser on the same computer used to interact with the simulation.

In the web portal, the trainees selected different tabs to obtain information needed to properly interact with the simulation environment. The tabs were

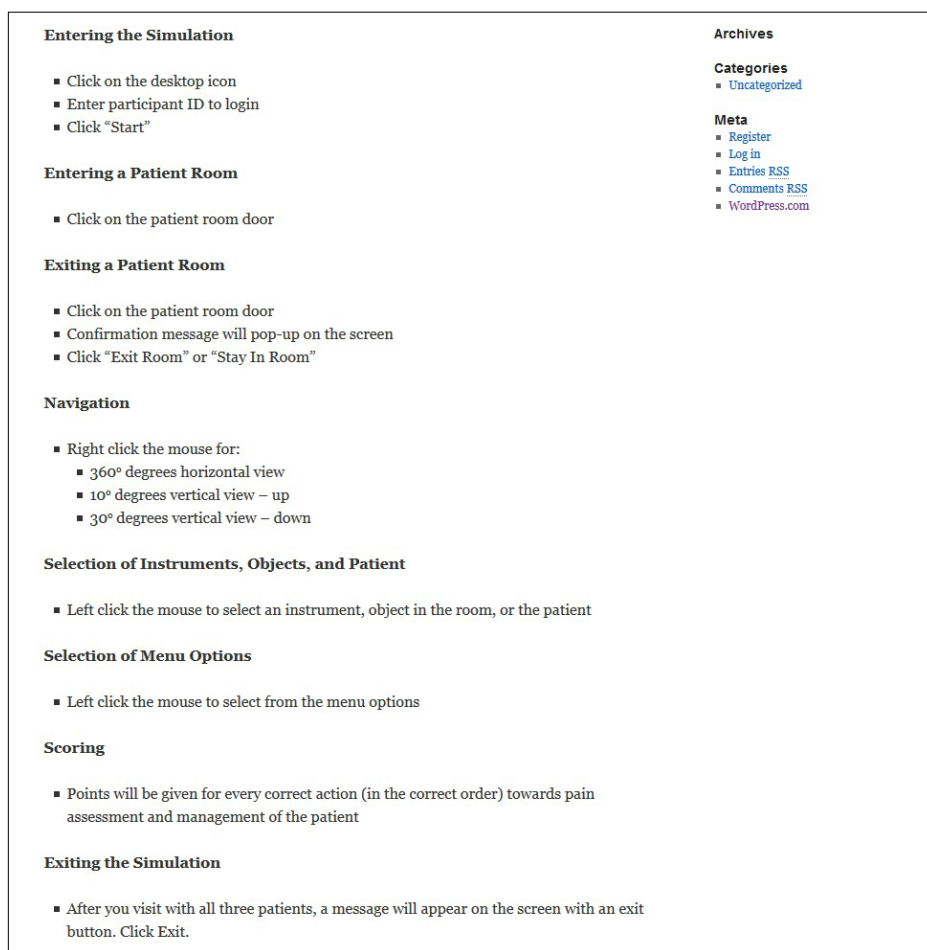
labeled: introduction, objectives, scenario, and instructions. Under the introduction tab the learners are informed about the title of the 3D simulation, their role as trainee in the simulation interaction, and broad goal of the simulation training (Figure 3). The objectives tab presented learners with the six detailed learning objectives of the simulation environment. The scenario tab provided learners with an in depth description of the scenario in the simulation environment.

Lastly, when learners select the instructions tab, they can read the instructions on how to enter the patient room, select objects in the rooms, exit a patient room, and exit the simulation. The instructions tab also explained how the trainees would be scored during their interaction with the simulation (Figure 4).





**FIGURE 3.** Web portal introduction.



**FIGURE 4.** Web portal instructions.

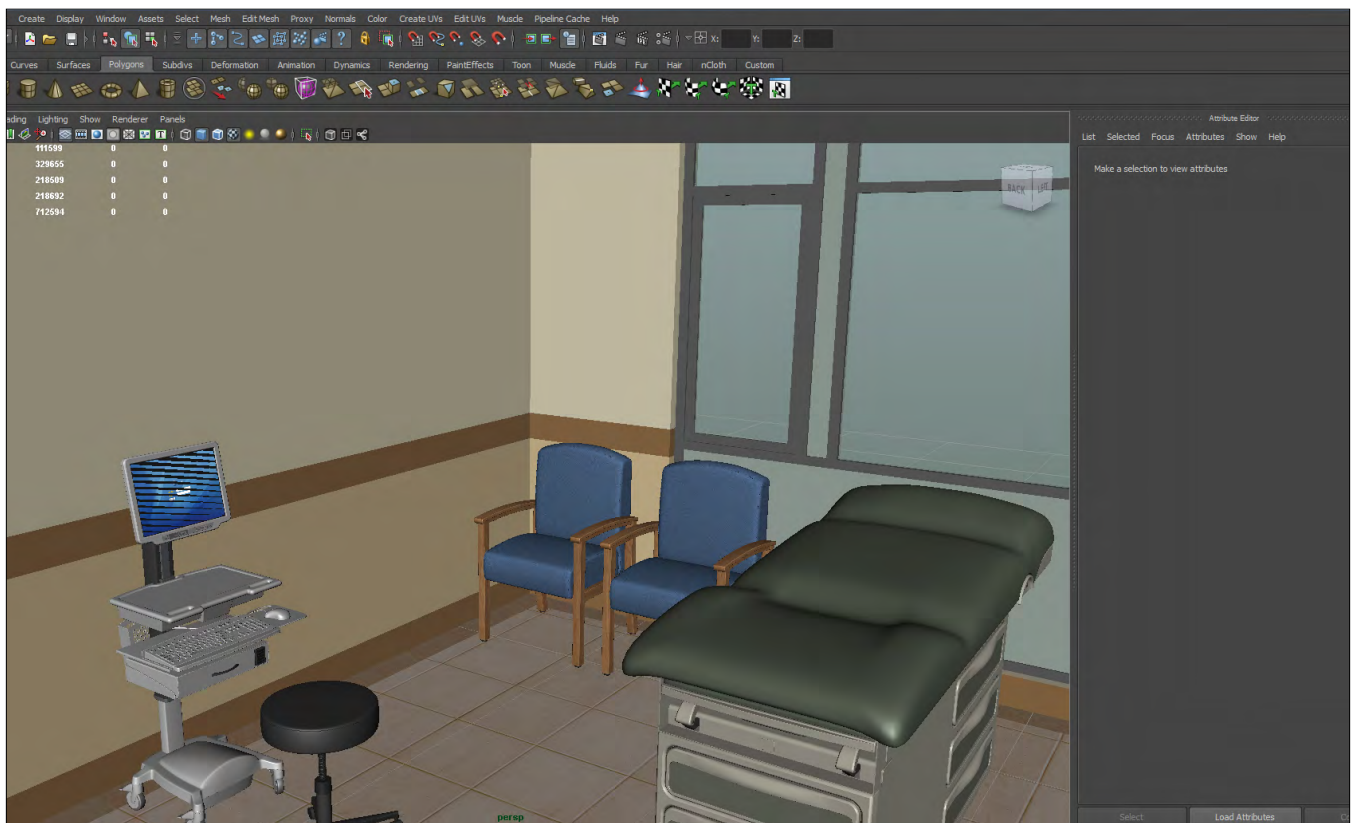
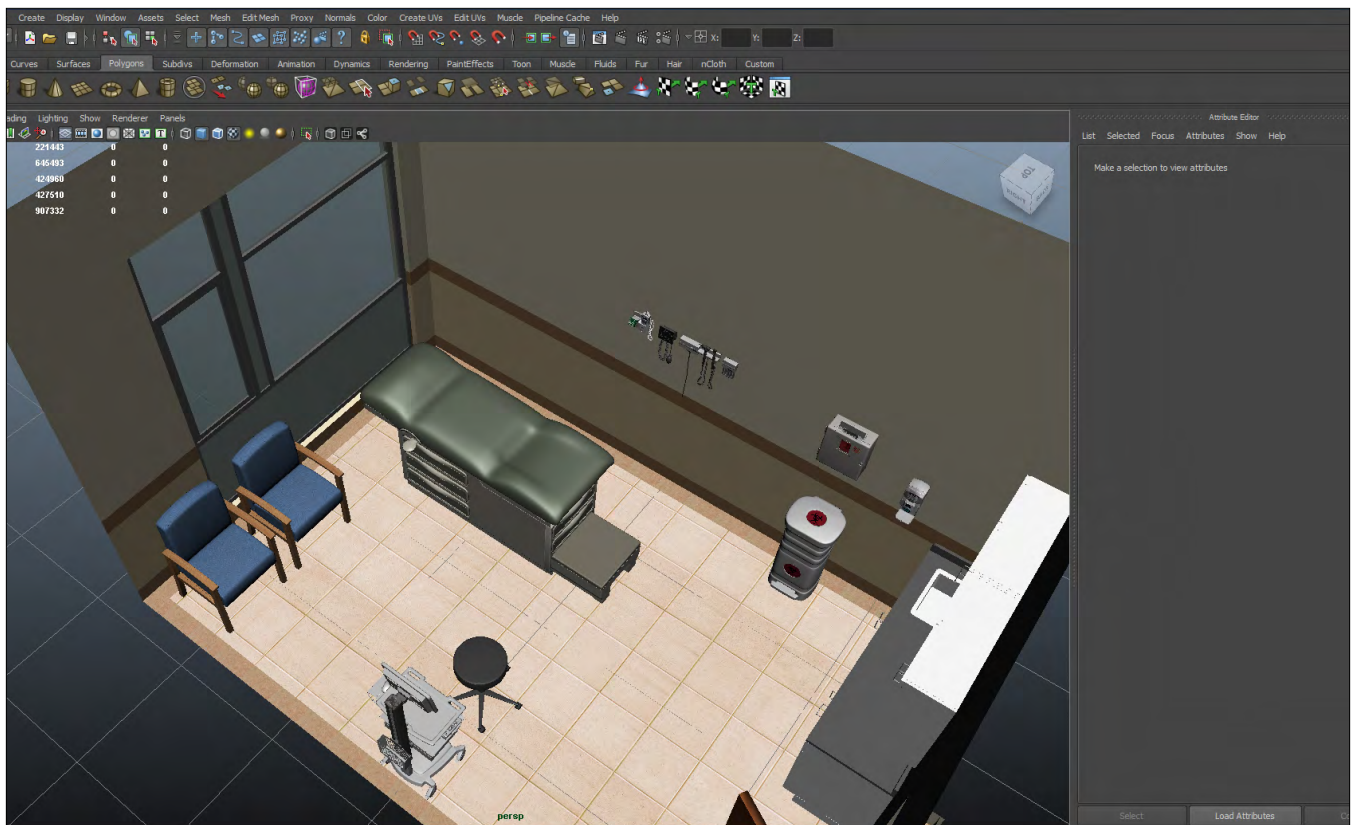
All trainees must view the information in the web portal before entering the simulation platform and starting the interaction with the virtual patients.

## DEVELOPMENT PROCESS

After six months of meetings and preparation of documentation, the team was organized to start the development process. During the development period, the visualization specialist used the bird's eye view mock-up of the patient room provided by the instructional designers to create a similar layout in the 3D environment using Maya 3D Animation (Figure 5a and 5b). The visualization specialist also used the images provided by the instructional designer to re-create a hallway with doors to each of the patient rooms.

Once the patient rooms and the hospital hallway were developed, the instructional designer and the visualization specialist captured the motion, facial, and audio behaviors of the virtual patients (Romero, Watson, Papelis, Garcia, & Croll, 2013). In order to make the body movement and facial expressions of the animated agents realistic and standardized, the team decided to hire a professional actor. Each motion capture and facial expression capture was completed in separate sessions for each animated agent, ideally allowing the actor to focus on the behaviors, emotions, and body movements of one of the virtual patients. Funding for the service of the actor was provided by the instructional design and technology faculty member's research budget.

The team captured the motion of the virtual patient using the OptiTrack Optical Motion Capture System (Figure 6) and processed with AutoDesk Motion Builder. This software allowed 3D object



**FIGURE 5A AND 5B.** Initial development of the patient room using Maya 3D Animation.





**FIGURE 6.** Motion capture using a professional actor.



**FIGURE 7.** Capturing the facial expression animations based on the motion capture.

motion tracking, real-time streaming, and a multi-camera configuration. The OptiTrack Optical Motion Capture System and the Autodesk Motion Builder software were available as a result of previous research projects to the visualization specialist, therefore it was a convenient method to capture and process the body movements of the virtual patient. The body movement animations for the virtual patients were captured in a one-week period. The visualization specialist devoted eight weeks to processing the animations for the body of the three virtual patients.

Once all the body movement animations were captured and processed, the team proceeded to capture the facial expressions and voice of the virtual patient simultaneously. The

team captured the facial expressions of emotion using the beta version of FaceShift software and an Xbox Kinect. The voice (audio) was captured using a simple iPhone audio recording application (Romero, Watson, Papelis, et al., 2013). The team was able to capture all the facial expression animations and voice (audio) in a three-day period. The visualization specialists processed the facial expression animations and voice (audio) in 4 weeks (Figure 7).

As mentioned previously in this paper, the project was an unfunded project. Therefore the majority of the resources used for the development of the simulation were those available in the institution, including: the Maya 3D Animation software, the OptiTrack Optical Motion Capture System, the Autodesk Motion Builder software, and the Xbox Kinect. The visualization specialist recommended using the iPhone audio recording application due to its high quality recording capabilities and availability to the team, he volunteered his iPhone during the recording process.

For the development process, the team was only required to purchase one piece of software, FaceShift. At the beginning of the project, the FaceShift software was available for download at no cost from the company's website as a Beta version. However, as the project progressed and development phase started, the visualization specialist notified the team that the beta version of the software was not longer available and provided information about the cost for the purchase of the FaceShift software. Research funds from the faculty members in the design team were used to purchase the software.



**FIGURE 8.** Rendering of the 3D Simulation.

### Validation of the Animations

To confirm proper rendering of pain behaviors for each animated agent, the instructional designer conducted a validation study (Romero, Watson, & Papelis, 2013). The validation study served as formative evaluation to assess the effectiveness of the scenarios prior to the implementation of the simulation. The instructional designers conducted the validation process using a web platform. The participants were 10 nursing professionals with experience in pain assessment and management. The team presented the participants with nine simulated patient animations using a web-based interface. Each animation had different pain intensity levels. The instructional designer provided a visual analog scale to the participants to rate the pain level portrayed by the animated agent in each animation and to explain the observed cues that lead to this rating.

The results indicated that none of the videos were given a very low or high pain level rating (Romero, Watson, & Papelis, 2013). The majority of animation videos were rated with a moderate pain level (emotion intensity) regardless of the pain rendering simulated. Some of the participant's comments shed light on the results for each video animation. The designer and development team made modifications and improvements to the nursing simulation based on the input from the nursing professionals participating in the study.

### Final Development and Programming

After the initial development of the virtual environment and the completion of the animations for the virtual patient, the visualization specialist used the Unity 3D Game Engine to integrate the 3D virtual environment and the animated virtual patients (Romero, Watson, Papelis, et al., 2013). Subsequently, the programmer wrote the code to program an interactive point and click system for the clickable objectives in the patient room. The programmer also wrote the code to create an interactive pain assessment interview between the trainee and virtual patient, including triggers to the virtual patient's emotion-like animations. Additionally, the programmer wrote code to allow virtual movement of the trainee in the patient room and between patient rooms. Lastly, the programmer wrote code to allow storage of detailed logs, including actions and points obtained for each action of each trainee, reviewable by the instructional designer/researcher.

### Usability Testing

Following the development of the simulation in Unity 3D (Figure 8) and the finalization of programming code, the instructional designer reviewed the usability of the simulation. Using the performance measures for the trainee, the instructional designer used the clickable objects to correctly conduct the pain assessment of the virtual patient, including the pain assessment interview, and to manage the pain symptoms. In an effort to ensure all interactivity was

completely functional, the instructional designer conducted the pain assessment and management process a second time, using both correct and incorrect pain assessment procedures in all three patient rooms. After the activity with the 3D simulation, the instructional designer reviewed the simulation logs to verify the accuracy of the logs.

Based on this usability testing, the instructional designers communicated with the programmer to address a few changes in the simulation code that would help improve the 3D simulation, including: correct spelling of certain words, correct grammar in a few sentences and change of images for a few clickable objects. The programmer also made corrections to the simulation log for a more accurate and detailed depiction of the actions and points that the trainee could obtain during their interaction with the 3D simulation.

After all corrections were made to the simulation environment and the programming code, the instructional designer saved the files to the simulation environment on the research computer the trainees would use for the simulation. The instructional designer also created a desktop shortcut or icon for easy access to the file.

## CONCLUSION

This case provides an overview of the design and development process including a 3D interactive simulation with emotionally expressive animated agents. The topic of the simulation was related to pain assessment and management education and training. Although the topic of the simulation related to nursing, the design and development processes followed for this project apply to other fields and scenarios integrating animated agents.

These design and development processes produced an effective simulation that met the learning objectives specified for the trainees. It also assisted in the creation of a realistic environment with animated agents that portrayed human-like emotions. The team had to make a significant number of decisions to reach the desired outcome taking into consideration the time and resources available.

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## APPENDIX A

### Simulation Objects Handout (Front and Back)



#### Simulation Environment Clickable Objects

|      |                      |
|------|----------------------|
| Room | Computer             |
|      | Hand Sanitizer       |
|      | Medication Bottles   |
|      | Sink                 |
|      | Stethoscope          |
|      | Blood Pressure Cuffs |
|      | Phone                |
|      | Pulse Oximeter       |
|      | Thermometer          |
|      | Cardiac Monitor      |



**Simulation Environment  
Clickable Objects**

|         |                              |
|---------|------------------------------|
| Patient | ID Band                      |
|         | Patient Chart                |
|         | Allergy Band                 |
|         | Pain Assessment Interview    |
|         | Non-Medication Interventions |
| Room    | Weight Scale                 |
|         | Chairs                       |
|         | Pain Poster                  |