A PROPOSED APPROACH FOR TESTING AN EDUCATIONAL VIRTUAL REALITY SIMULATION FOR END-OF-LIFE CARE

by

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Presented to the Faculty of the Honors College of

The University of Texas at Arlington in Partial Fulfillment

of the Requirements

for the Degree of

HONORS BACHELOR OF SCIENCE IN COMPUTER SCIENCE

THE UNIVERSITY OF TEXAS AT ARLINGTON

May 2022

ACKNOWLEDGMENTS

I would like to extend my sincere thanks to my faculty mentor Shawn Gieser. He provided guidance and was helpful in suggesting ways to improve our workflow and project implementation. Thanks should also go to the sponsors and creators of the project idea, Jennifer Roye and RaeAnna Jeffers. They helped in every way from the conception of the idea to helping with the implementation of Nursing practices. I also had the great pleasure of working with four team members including Arwa Jafferji, Matthew Irvine, Alexis Lueckenhoff, and Lucas Streanga. We have worked very hard together to tie up the loose ends of this project and create something we are proud of. I would also like to acknowledge those who have worked on the simulation in the past as part of their Senior Design projects. Without that foundation, we would have a lot more to work on.

April 20, 2022

ABSTRACT

A PROPOSED APPROACH FOR TESTING AN EDUCATIONAL

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FOR END-OF-LIFE CARE

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The University of Texas at Arlington, 2022

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Virtual Reality (VR) is becoming more popular with the continuous introduction of newer and more capable technology. Specifically, VR educational simulations can provide training on complex situations that may be difficult to carry out in real life. In an attempt to improve the quality of end-of-life care knowledge among nursing students, a VR simulation is in development that presents related scenarios nurses may face. Rigorous testing of this simulation is essential to produce effective results that separates itself from 2D simulations or other educational methods. A testing framework and plan is proposed here that can be extended to future VR educational simulations. Methods to validate the use and execution of VR are analyzed. A description of how the test plan was developed is also given. By testing VR simulations robustly, VR technology will be more successful in

predicting positive learning outcomes and therefore transitioning to this new technology will be convincing and worth it.

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CHAPTER 1

INTRODUCTION

1.1 Paper Overview

With the advancement of technology and the potential to create new experiences virtually, how can traditional methods of education be superseded? Moreover, is it possible to produce effective and practical simulations that provide better results than tried and true methods? While one can subjectively answer yes or no, it is necessary to test simulations in order to get closer to producing ones that work and are practical for the target user.

This paper examines the honors contribution to my senior design group project which was an educational VR Nursing Simulation. The honors contribution consists of a proposed test plan covering accessibility, experience, and objective testing for that simulation. This test plan is intended to contribute to the field due to its ability to be extended to other VR educational simulations and used as reference. With better test plans for educational VR simulations, it will prove the worthiness of VR and therefore be easier to integrate it into current teaching practices and provide a new way of learning.

The paper is structured as follows: Chapter 2 talks about the purpose of using VR, testing areas, and current testing methods. Chapter 3 describes the methodology of creating the test plan. Chapter 4 will explain statistics of creating the test plan as well as the test plan itself. Lastly, Chapter 5 will draw conclusions on the current state of utilizing VR technology and why testing is imperative for educational VR simulations.

CHAPTER 2

LITERATURE REVIEW

2.1 Using the VR Medium

2.1.1 Implications of Using VR

The use of VR simulations can allow people to reach beyond the limits of their environment to experience something novel. In particular, the use of educational VR simulations has provided the opportunity to understand concepts related to the area of interest in new ways. There are many examples of effective VR such as dissections of animals, simulations of historical events, language-learning experiences, and medical simulations.

2.1.2 Advantages and Disadvantages of Using VR

Using VR as opposed to other mediums has advantages and disadvantages. Some advantages include immersion, deeper engagement with content, and most importantly, simulating things that are difficult or impossible to test in real life. On the other hand, VR disadvantages may include expensive hardware, accessibility constraints, difficult to adapt to, and more complex to develop. Therefore, it is important to utilize the VR medium to its fullest extent to make sure the advantages exceed the disadvantages. For instance, would the benefits of a cooking simulation (low-cost ingredients, unlimited kitchen space, access to different cookware) exceed the shortcomings of the simulation (cannot taste the food, lack of temperature changes, cannot smell the food)? There are situations in which the capabilities outweigh deficits such as flight simulations due to being a “low-cost,” and “highly realistic training” that have proven to “decrease the time to master a skill”, “improve procedural memory”, and enhance overall performance (Fussell et al. 2015).

Furthermore, it is useful to use VR in scenarios where it is not ethical or allowable to carry it out in real life. For example, it would not be ethical to perform surgery on a patient for learning purposes only. It is practical for surgeons in training to sit in during surgeries to observe, however, this does not allow time flexibility or the ability to experiment with the environment at hand. VR would be appropriate because the real-life equivalent would not be.

2.1.3 Replacing Reality with VR

Lastly, as successful VR demonstrates, it does not have to be used to replace real life. With the current state of technology, VR and Augmented Reality (AR) can be used in supplement with real learning experience to increase performance while imposing less limitations than doing the experience in real life. For example, a medical surgeon simulation can be used in conjunction with observing real surgeons in order to allow the student to exercise kinesthetic and visual/auditory learning styles.

From another perspective, simulating every action in real life can be very computationally expensive for potentially little payoff. For example, although it may be important to add a convincing level of graphics to a VR simulation, real-time lighting and shadows can lead to degradation of framerate and performance. Additionally, fixation on detailed and realistic environments “may have little relationship with functionality, especially in the context of VR for education and training” [6]. The immersion of VR can instead be accomplished by focusing on the senses such as hearing ambient sounds and touching objects to interact with them. Opting for a persuasive amount of reality in VR allows users to feel fully immersed while making good use of limited resources.

2.1.4 Distinguishing VR from 2D Alternatives

In order for VR to separate itself from 2D simulations, it must be able to provide experiences that act as an extension of the body and provide more autonomy to users to interact with their environment. One of the major deficits of 2D simulations is the fact that they cannot simulate reality nearly as well. Although for some people using a keyboard feels like an extension of themselves, it may not be as intuitive to press a button on a keyboard to hold a tool than to grip the tool with your hand. When new users try VR for the first time, they instinctually will try to grab things around them or look around to explore their new environment. The fidelity of VR technology would be able to surpass 2D simulations by being a closer experience to real life.

2.1.5 Limits and Constraints of VR

With the promises of VR also comes the limitations that may cause challenges in creating a seamless transition to the new technology. One area to consider is the target group's most common characteristics in order to design for them. For example, if the target group is young children, it may be better to test that the interface is easy to use and there are many ways to achieve the goal.

Furthermore, it is important to consider the accessibility issues with VR and consulting documentation or standards when testing the application. Some people may experience dizziness, sickness, or self-injury when using VR and by testing among many people, the chances of issues can be significantly decreased.

Cost is also an important factor for implementing VR as well. The cost can vary widely with VR headsets. When considering headsets supported by the open-source API for VR called OpenXR, the prices range anywhere from $299 for the Oculus Quest 2 to $3,500 for the Microsoft HoloLens 2.

2.2 Measuring Effectiveness of VR

2.2.1 Experience Testing

In order to verify the fidelity and effectiveness of a specific subject in VR simulations, the testing process should include some way to gather results of the simulation. In one meta-analysis covering the effectiveness of VR in Nursing education, they utilized various key indicators including knowledge, skills, satisfaction, confidence, and performance time [3]. These key indicators can be extended to other training simulations and are dependent on the intended outcomes of the simulation.

Moreover, it is also feasible to conduct experience testing with the target group of the product. Here, there should be an identification of control groups and experimental groups. The meta-analysis included 12 studies which used control groups consisting of those using non-VR or traditional education methods and experimental groups consisting of those using the VR simulation or some combination of traditional, non-VR, and VR.

After determining key indicators, it is important to create an assessment for them. In Nursing, it is typical to use post-simulation assessments in which the nurses can display their knowledge. This can work for both control and experimental groups. Other ways to test for key indicators could be to have each group perform simple tests that are related to the key indicator such as performing the skill in a new setting after some time has passed to test the proficiency of the skill.

Quantitative comparison is the strongest attribute for these assessments, but qualitative comparisons could also be used given the field. This is dependent on the nature of the field and if it is of summative or formative nature. Some are both and therefore assessments can have both subjective and objective results.

2.2.2 Accessibility Testing

In order to gain something from educational simulations, there must be testing for the usability of it. This covers the likelihood of getting sick or feeling dizzy while using the simulation. This also includes self-injury which may be caused by a lack of adequate room or running into peripherals. Additionally, eye strain and headache could be caused by extended use of the simulation. It is also important to consider those who need glasses in order to use the simulation and what they would be provided or what they could obtain to assist them in using the simulation. For example, there are virtual reality glasses lenses that could be purchased or headsets that can fit over glasses.

Likewise, it is imperative to consider those who are disabled and their ability to complete the simulation. For those who are colorblind, can the purpose of the simulation still be achieved? Choosing color combinations for UI that are easy to see for those who are visually impaired can make the simulation more accessible. In the same manner, the entirety of the simulation should not be based on hearing to avoid providing a less immersive experience for those hard of hearing.

Another concern for accessibility is making sure the VR simulation is not overwhelming to the user. Since the simulation is prone to mimicking real life, there should not be too many sensory inputs to where the user is confused about what they are supposed to be doing. This includes leaving out unnecessary visual details and not adding too many sound layers. This makes it easier for those with learning disabilities and those who tend to get distracted by too much input.

2.2.3 Objective Testing

Objective Testing can be done by decomposing learning objectives into actionable steps that the tester can take. The gamification of simulations is not always imposed on users and therefore it can be difficult to understand the flow of the simulation. For example, Lockheed Martin created a VR educational simulation called "The Field Trip To Mars" [12]. It turned an old yellow school bus into a VR tour covering 200 miles of the Martian surface. An example learning objective here could be "Students understand the abiotic nature of Mars as compared to Earth". This objective can be decomposed into actions and added to the test plan such as "Observe the lack of fauna and flora on the Martian surface". There is not a specific set of instructions the students are supposed to complete during this VR simulation but rather an observation of their environment.

In simulations where there exist specific steps the user should take like in medical simulations, it may be easier to decompose learning objectives into actions. For example, post-mortem care involves a series of steps including the pronouncement of death, cleaning the patient's body, changing the patient's clothes, providing a viewing if requested, etc. Here, these actions can be added directly to the test plan and grouped by learning objective. For instance, an objective for postmortem care could be "Nurse can provide a viewing for the family post-mortem" and its actions could be "Provide chairs and water for the family", "Change the patient's clothes and replace bed sheets", "Remove jewelry and gather items requested by family for the viewing", etc.

2.3 Current Testing Methods

Although there is not an all-encompassing testing framework for VR simulations, there are various tools and methods that can be combined to robustly test them. Below are a few established methods.

2.3.1 Simulator Sickness Questionnaire

The Simulator Sickness Questionnaire (SSQ) was developed in 1993. There are a multitude of symptoms associated with side effects that some may experience while using VR [9][14]. Each symptom has 4 possible levels, ranging from 0 which is none to 3 which is severe, that a person answering can use to describe the severity of the symptoms. The symptoms seem to cover just about all the major associated problems that can occur with VR users, like fatigue, eye strain, and dizziness with both eyes open and closed. The questionnaire then takes these scores and totals them up with 3 different classes of symptoms which are nausea, oculomotor, and disorientation [15]. It then takes the classes of symptoms and weighs them to give a score for each class and a separate total score.

2.3.2 System Usability Scale

The System Usability Scale (SUS) is a simple and fast reliable tool for checking usability [13]. It is a ten-item questionnaire with five response options for those taking the questionnaire. Though it was created in 1986, it remains a tool used to evaluate a wide variety of products and services from software and hardware to mobile devices and applications. SUS is the industry standard with over 1300 publications and articles. The benefits are that it is simple scale to give to the participants, and reliably show the feelings of even a small number of participants, and it can differentiate between usable and unusable systems. While there are many benefits, there are some downsides. The scoring system has been called complex; the score is reminiscent of percentages even though that is not true. When using SUS, it is best practice to normalize the scores and then make a percentile ranking, however it should be known that the tool is not to be used to diagnose any issues, it simply classifies the ease of use of whatever is being tested. Here are some of the questions asked on the questionnaire: “I thought the system was easy to use”, “I found the system very cumbersome to use”, and “I would imagine that most people would learn to use this system very quickly.” When it comes to interpreting the scores of SUS, the scores are given a 0-100 score. Although not a percentage, based on research, a score above a 68 is considered above average and a score below 68 is below the average. Still, the best way is to normalize the scores and rank each by percentile.

2.3.3 The Game User Experience Satisfaction Scale

The Game User Experience Satisfaction Scale (GUESS) is a 55-item tool used to find the satisfaction that a person can get from a video game [7]. It is a versatile tool although two studies were conducted deeming that for some games all 55 questions assessing 9 video game constructs was cumbersome. The study cut the 55 questions to an 18-item version of GUESS. Although this tool is useful, it is not as applicable because most questions are related to high fidelity experiences which are not as relevant for VR educational simulations.

CHAPTER 3

METHODOLOGY

The following section will describe an overview of the simulation that the honors contribution was based on as well as how the test plan was developed.

3.1 Description of VR Nursing Sim

3.1.1 VR Nursing Simulation

The current U.S healthcare system is poorly designed to provide the comforting care that people prefer towards the end of their life. In addition to this, nurses have frequently reported feeling ill-prepared in providing end-of-life care of all ages. To combat this, a VR simulation is being developed for nurses to gain knowledge in palliative care prior to entering the field. This VR Nursing Sim presents four scenarios to the user and the test plan presented here covers the first two scenarios.

The simulation deals with the in-hospital and at-home care of the elderly patient, Mr. Russell. In the first scenario, Mr. Russell is in the hospital and the nurse needs to perform a number of steps in order to provide proper care to Mr. Russell including calling for doctor's orders and administering pain medicine. There are also standard precautions the nurse should practice in the simulation such as washing their hands, performing a focused assessment, following the five rights of medication, and wearing PPE to protect the patient.

Following the in-hospital scenario, the patient is discharged to at-home palliative care and the nurse is required to provide that care for Mr. Russell. In the second scenario specifically, the nurse must identify potential hazards to Mr. Russell including fire hazards, tripping hazards, and health hazards. The following two scenarios deal with the impending death and post-mortem care of Mr. Russell. However, since these two scenarios are not covered in the test plan presented here, they are considered out of scope and will not be discussed further.

3.1.2 State of the Project

Currently there are two teams working on the VR Nursing sim called MediSim and NurSim. There have been teams who worked on the project as a part of their senior design course. In previous years, with the pandemic, there was not any VR implemented into the simulation. It was implemented as a 2D simulation with text options to choose from. In the succeeding years, the project was ported to Unity's VR platform and further integrated with the open-source API, OpenXR. This design decision was to enable the simulation to work cross platform. The team prior to our team (MediSim) focused on the development of the first two scenarios and developed it to a considerable extent. There has been no testing done for this project yet. The project was not completed at any point and is projected to be complete Fall 2022 (including testing). The product is currently being developed on the HTC Vive 2 headset in the senior design lab at University of Texas at Arlington.

3.2 Testing for VR Nursing Sim

3.2.1 Experience Testing

3.2.1.1 Key Indicators

As mentioned previously, key indicators are goal specific to a test plan. Here, the only indicator for the test plan would be knowledge. Due to the sponsor's communication of a formative assessment in the simulation, knowledge will be the indicator of success for this simulation.

3.2.1.2 Control Groups

The test plan is intended to be used with one control group and two experimental groups. Each group will be chosen at random from a specific year of nursing to ensure the nurses all have the same relative knowledge regarding palliative care. The control group will be a group of nursing students who learn palliative care knowledge through the smart lab/hospital or traditional methods of education. The first experimental group will be a group of nursing students who only use the VR Nursing sim. The second experimental group will be a group of nursing students who use the VR Nursing sim in conjunction with the smart lab/hospital and traditional methods of education.

3.2.1.3 Assessment of Knowledge

Due to the lack of domain-specific knowledge from developers, there is an assumption that the experts in the field (sponsors or others in the nursing department) will create debriefing assessments for the nurses to take. Therefore, there has been no test cases generated for experience testing. There has been one assessment developed to be completed after doing the first scenarios that consist of open-ended questions including “What is needed to prepare for your visit to Mr. Russell’s home today?” and “What orders do you anticipate from the hospice physician?” Although this is not in the scope of this project, it is possible to add a summative assessment with these questions in order to quantitatively measure the results of each group.

3.2.2 Accessibility Testing

To generate test cases for accessibility testing, the Virtual Reality Check by Oculus, the W3C XR Accessibility User Requirements, and the Simulator Sickness Questionnaire were used. Because a high percentage of VR use is currently for gaming, objectives which were not relevant to the simulation at hand were omitted. Moreover, due to the limited scope of this project (two semesters and $800 budget), infeasible objectives were also left out. Some test cases were generated based on the literature review discussed above.

3.2.3 Objective Testing

Due to the nature of the VR Nursing simulation, the objectives were based on the learning objectives and the actions were easily obtainable by using the flow of the simulation. There were 17 test cases generated based on the steps that need to be taken by the nurse in each simulation.

CHAPTER 4

DISCUSSION

4.1 Results

Table 4.1: Objective Testing Test Cases, Objective: Use Five Rights of Medication

#	Objective	Steps to Test	Expected Result
1	Confirm identify of patient	1. Check patient arm band 2. Ask patient for name and DOB using dialogue system	Dialogue response should match patient armband "Benny Russell, 06/26/1943"
2	Choose right drug to administer	Refer to doctor's orders to pick the right drug	Be prompted with multiple medication options and choose Morphine
3	Choose right dosage to administer	Refer to doctor's orders to pick the right dosage	Be prompted with multiple dosage options and choose 5mg
4	Choose right route to administer	Observe ways to administer medication in environment	Administer medication through the IV or syringe
5	Choose right time to administer	Use knowledge to pick right amount of time to administer drug	Be prompted with multiple medication options and choose 1-2 minutes

In Table 4.1, the test cases generated display the decomposed actions from the objective "Nurses will utilize five rights of medication". The expected results were generated by following the scenarios descriptions. Both items were given by the sponsor and expert in the field, Jennifer Roye. The full objective testing test cases can be found in Appendix A. It includes 21 test cases that are based on scenario flow and learning objectives for the first two scenarios.

Table 4.2: Accessibility Testing Test Cases

#	Objective	Steps To Test	Expected Result
1	Judge overall severity of cybersickness experienced by user	Play through scenario 1 or 2 and complete the Simulator Sickness Questionnaire	Score should fall between 0 and 1 for those who have used VR before and are not prone to VR sickness, and below 2 for those prone to VR sickness and/or have not used VR before
2	De-emphasize the need to use your body to control the VR experience; have a range of input mechanisms	Use the controller to walk forward and/or teleport throughout Scenario 1 or 2	User should be able to control movement within the simulation without physically moving to walk around
3	Text and in-app controls and elements necessary for app progression should be clearly legible. When possible, provide options for increased contrast and/or larger UI elements	Utilize a color accessibility checker to verify the UI is easily visible (one available here:https://webaim.org/resources/contrastchecker/)	Ensure colors pass WCAG AA and WCAG AAA requirements

In Table 4.2, areas of accessibility covered include cybersickness, movement and control, and visibility. There are 11 total test cases generated for accessibility testing which can be found in Appendix B. With all test cases, the coverage increased to include the issue of sensory overload with VR, digital wellbeing, and physical fidelity [6]. Note that Experience testing test cases were not generated due to the assumption that the Nursing department will create assessments to be used and utilize the control group/experimental model laid out in Chapter 3. The yellow highlighted tests indicate that they were referenced from the Simulator Sickness Questionnaire (SSQ) [14]. The SSQ should be utilized as a tool to test the fatigue, eye strain, dizziness, etc. of the user after they test the scenario. The blue highlight indicates tests that were self-generated. The green highlight indicates tests that were referenced by the VRC by Oculus [1].

4.2 Relevance of Test Plan

4.2.1 Importance of Software Testing

It is pertinent to test the quality of software before its release for many reasons. One major reason is to avoid software failures post-deployment which in some cases can lead to life-threatening situations. While the VR Nursing project is generally not risky, not allotting proper room for the simulation could lead to dangerous incidents.

Another reason software testing is important is to make sure user requirements are being satisfied. Usually, the requirements are enumerated in a document called the System Requirements Specification. There are other documents like the Architectural Design Specification and Detailed Design Specification that can also be verified.

Lastly, given the nature of this project, testing will be an important step to gear this project towards completion. It is meant to check the correctness and completeness of the product which will allow this product to be deployed.

4.2.2 VR Nursing Future Plans

As mentioned earlier, the intended finish date for the VR Nursing simulation will be Fall 2022. By the end of this summer, the project is intended to be packaged and ready for testing. Therefore, this plan should be able to be utilized by the Summer 2022 – Fall 2022 senior design team. They should be able to work in conjunction with the nursing department to fully test the project. This project is intended to be used as a supplement to the smart lab/hospital simulations so those groups may benefit from viewing their simulations before testing.

4.2.3 Limitations and Constraints of Test Plan

The identification of groups is unknown and therefore there are no roles assigned for who will develop the assessments to be used. Moreover, platform changes and choice of distribution prevents a description of how to distribute the SSQ. Additionally, it is unrealistic to utilize long questionnaires because of both budget and time constraints for the project. A large-scale testing effort may include the use of long questionnaires.

Being a developer on the project and understanding the depth and scope of the project, some tests for accessibility were left out to allow this project to be completed and tested within a reasonable time. For example, implementing light sensitivity adjustments or realistic physics may severely delay the project. Furthermore, this project has the unique quality of entirely changing groups every two semesters, so the knowledge of intricacies and inner project workings are lost if not documented. For example, there is no gap to train the incoming team on the Unity OpenXR platform and therefore the implementations can look vastly different, and the file structure can become difficult to navigate. For these reasons, it was important to leave tests that were feasible but still achieved the goal of the simulation and justified the use of the VR medium.

CHAPTER 5

CONCLUSION

There are many reasons to transition to new technologies especially when they are offering advanced capabilities and the chance to contribute to human knowledge. Despite this, it can be difficult to convince those used to traditional education methods to utilize a new form of teaching. Cost and time are also big factors when transitioning to new technologies. In spite of this, it is important to provide practical and high-quality options with new technologies in order to help convince those to switch to new technologies. In order to do this, in-depth testing is required. Additionally, research on testing frameworks and the development of feedback questionnaires assist in improving testing practices.

APPENDIX A

OBJECTIVE TESTING FULL TEST PLAN

Scenario 1

#	Objective	Steps To Test	Expected Result
1	Obtain context about Mr. Russell's medical history	Read pre-briefing before the simulation starts	Understand symptoms, timeline of symptoms, and potential causes of symptoms.
2	Obtain medical history from Mr. Russell	Use Electronic Medical Record on computer next to Mr. Russell	See age, weight, DOB, and allergies of patient. See Active orders for the patient as well as patient history and current patient report
3	Greet Mr. Russell	Use dialogue system to introduce yourself to Mr. Russell	Be able to give your name and title to Mr. Russell
4	Confirm identity of Mr. Russell	Check patient armband	Verify Mr. Russell's first and last name and DOB
5	Wash and dry hands	Run hand under sink and grab paper towel to dry	Sink should run normally, and paper towel should be grabbable
6	Wear gloves and mask	Wear PPE by interacting with glove box and mask	It should be indicated that gloves and mask are on (pop-up message, hands change color)
7	Check vital signs of Mr. Russell	Use monitor by Mr. Russell to view vital signs	Obtain heart rate, SP02, RR, blood pressure, temperature, and pulse strength from screen
8	Listen to Mr. Russell's lung and heart sounds	Use stethoscope to obtain information about lung and heart sounds	Hear or see feedback about Mr. Russell's lung and heart sounds and be able to distinguish results
9	Observe patient for changes in skin color	Observe Mr. Russell's body for any changes of skin color	Observe no changes in skin color and have the ability to report or confirm that result
10	Determine temperature changes on various parts of the body	Use temp of extremity by pressing on skin and measuring the time it takes to go back to a normal skin color	Observe 3-4 seconds (indicating he is sick)
11	Ask patient about pain	Use dialogue system ask patient about level of pain	Patient should respond with high level of pain
12	Call doctor to get pain medicine	Use phone to call doctor and dialogue system to get new doctor's order	Understand new doctor orders and move on to medication administration
13	Choose right drug to administer	Refer to doctor's orders to pick the right drug	Be prompted with multiple medication options and choose Morphine
14	Choose right dosage to administer	Refer to doctor's orders to pick the right dosage	Be prompted with multiple dosage options and choose 5mg
15	Choose right route to administer	Observe ways to administer medication in environment	Administer medication through the IV or syringe
16	Choose right time to administer	Use knowledge to pick right amount of time to administer drug	Be prompted with multiple medication options and choose 1-2 minutes
17	Maintain sterility of needle when administering medication	Do not touch needle to any contaminated surface; Touch to contaminated surface	No warning message; warning message

Scenario 2

#	Objective	Steps To Test	Expected Result
1	Ring doorbell to enter Mr. Russell's home	Use hand to press doorbell	Sound should play and door should open greeted by Mrs. Russell
2	Identify trip hazards in the house	Interact with trip hazards (plant)	Indicates to the user that the hazard has been remediated by animating item upright
3	Identify health hazards in the house	Interact with health hazards (dirty dishes, moldy bread, wine, dirty trash, gas heaters, pill bottle)	Indicates to the user that the hazard has been remediated by cleaning the item or making it disappear
4	Identify fire hazards in the house	Interact with fire hazards (candles)	Candle flames should disappear as if being blown out

APPENDIX B

ACCESSIBILITY TESTING FULL TEST PLAN

#	Objective	Steps To Test	Expected Result
1	Judge overall severity of cybersickness experienced by user	Play through scenario 1 or 2 and complete the Simulator Sickness Questionnaire	Score should fall between 0 and 1 for those who have used VR before and are not prone to VR sickness, and below 2 for those prone to VR sickness and/or have not used VR before
2	VR Simulation is compatible with those who are visually impaired	Wear average sized glasses and play through scenario with headset over the glasses. Score discomfort as 0 - no discomfort 1 - some discomfort 2 - uncomfortable	Score should remain at 0 or 1 while playing both simulations
3	Text and in-app controls and elements necessary for app progression should be clearly legible. When possible, provide options for increased contrast and/or larger UI elements.	Utilize a color accessibility checker to verify the UI is easily visible (one available here:https://webaim.org/resources/contrastchecker/)	Ensure colors pass WCAG AA and WCAG AAA requirements
4	Avoid overwhelming users with sound layers	Count number of simultaneous sound layers during scenario 1 and 2	Sound layers should not exceed 3
5	Smoothness of simulation	Play through scenario 1 or 2 without crashes, freezes, or extended unresponsive states	Should not encounter any crashes, freezes, or unresponsive states
6	Application should be playable in its entirety without the use of audio or provide subtitle options for in-application dialogue and/or sound effects to communicate progress to the user.	Play through the application content without audio and verify that you see subtitles for dialogue and sound effects	Application should be playable with no audio or should provide subtitles for all dialogue and sound effects.
7	Applications should provide the user with the option to rotate their view without physically moving their head/neck.	Confirm you are able to move the player view without physically moving your head/neck	People should be able to rotate the camera perspective/view without physically moving their head using their controllers or other methods.
8	De-emphasize the need to use your body to control the VR experience; have a range of input mechanisms	Use the controller to walk forward and/or teleport throughout Scenario 1 or 2	User should be able to control movement within the simulation without physically moving to walk around
9	VR Headsets should not need the user to be in a physical position to play	Play part of either scenario 1 or scenario 2 sitting down and then continue to play standing up	The user should not have to be in a particular physical position such as standing or sitting to play a game or perform an action. There should be ability to remap these physical positions to other controls.
10	Provide a platform integration with tools that support digital wellbeing, allow the user to access alarms for time limits during an immersive session.	Play for greater than 30 minutes	Observe a warning that supports digital wellbeing like an alarm that notifies they have been playing for a long time
11	In-application hands and controllers should line up with the user's real-world counterparts in position and orientation as closely as possible.	While using your app, hold your hands in front of your face and raise your headset slightly so you can compare your real-world hands and your virtual hands. Repeat this process with your hands at different angles and positions in order to observe and correct any disparities	In-application hands should match your real-world hands.

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BIOGRAPHICAL INFORMATION

Jasmine Hyder is an undergraduate student in Computer Science. Her intended graduation is in Spring 2022 with an Honors Bachelor of Science in Computer Science. Her academic career consisted of involvement in the Honors College, a leadership role in the peer led team learning program, and a software engineering internship. During her time in the Honors College, she was able to work on multiple projects including writing research papers about mutation testing and an overview of virtualization and the cloud. In addition to her regular curriculum, she took elective courses in software testing, software project management, human computer interaction, and game design. Her future plans are to work as a Software Engineer at JP Morgan Chase.