A CDM PROEJCT

CENTRE FOR DIGITAL MEDIA

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VCS Virtual Clinical Simulation

Enhancing Medical Training through Digital Innovation

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For Dr. Omamah Almousa

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Intro

Executive Summary

Dr. Omamah Almousa is a vascular resident at McMaster University. She approached the CDM to transform clinical medical tele-simulation into a virtual reality experience. Through advanced virtual reality tele-simulation, clinical training can be accessible in resource-limited areas overcoming the barriers of distance, time, personnel, and equipment.

Simulation is the process of recreating a contextual background for the purpose of learning. In medical training it allows the student to make decisions, experience success, make mistakes, receive feedback, and gain confidence in an environment that is void of patient risk. Research has suggested that simulation is a "powerful learning tool to help the modern healthcare professional achieve higher levels of competence and safer care"[1] however; there are several barriers that limit access to traditional medical simulation centres. Simulators are often located in urban centres and not easily accessible to those outside the centres due to geographic, cost and time constraints. Lack of clinical simulation training is more evident in remote regions of the world.

Virtual tele-simulations would allow for education and training in rural areas. Instructors could remotely manipulate the clinical scenario with the use of an instructor control panel. Students in rural areas could reap the benefits of simulation without the need of physical simulation centres. The virtual simulation would make training more feasible within an institution allowing for inter- institutional networking and collaboration and a novel education opportunity for medical students in developing countries.

Purpose

Our purpose and market niche is to transform traditional medical simulation training into a virtual experience to make it accessible to students in resource limited areas through the creative integration of advanced digital technology and tele- simulation. By making medical simulation more accessible, students located outside urban centres will be granted the ability to access this enhanced form of medical training.

Background

Simulation can enhance surgical and medical education by replicating clinical scenarios that are immersive and experiential. Advancement in medical workforce training with the use of simulation is expanding. Although this method of education can maximize learning outcomes, it is expensive and comes with limitations. Accessibility is limited due to geographic, cost and time and personnel constraints

Problem

The cost and distance barriers of traditional simulation centres makes access unfeasible for medical students in remote areas.

Project Goal/Purpose

Our purpose and market niche is to make medical simulation training accessible to resource limited areas through the creative integration of advanced digital technology and tele-simulation. By making medical simulation more accessible, students located outside urban centres will be granted the ability to access this enhanced form of medical training.

The use of a virtual simulator would allow students in remote areas the opportunity

- to practice their skills in a risk-free environment
- to master their techniques in a life-like scenario
- to improve their reliability to make the right decisions in real life
- to have access to a trained instructor in a totally different geological location

All of the above positively impacts patient safety and health.

Project Objectives

The goal of Team Inter-Vein is to develop a proof of concept prototype in VR for clinical tele-simulation training in resource-limited areas involving a remote instructor with an interactive control panel, for one trainee in the short-term and multiple trainees as a future goal.

Our primary area of focus for development is to create a VR environment of a trauma bay with a patient and the required medical tools. The experience will feature one specific medical scenario. Tools and patient conditions in the VR environment can be altered by an instructor from a desktop control panel. For this proof of concept, we aim to have a working prototype of the environment with required medical instruments and tools and the ability for the instructor to view simulation, place items, control vitals, audio share, and download the video for the debrief.

Short Term Objectives:

- **Accessibility**: feasibility of clinical training through digital enhanced simulation.
- **Tele-presence:** enabling educators and learners in remote locations to share virtual learning environments and overcome distance barriers.
- **UI controlling system** for instructor so the instructor can manipulate the scenario based on trainee's reactions

Long Term Objectives:

- **Multi-player:** The ability for more than one trainee to participate in the virtual clinical simulation simultaneously
- **High Fidelity:** Realistic patient, objects and environment

Chosen Technology

Oculus Quest:

1. **Easy and quick set up:** Oculus Quest works with the environment; you can stand or sit in spaces big or small.
2. **Wireless:** It's standalone and wireless, meaning it doesn't require a connection to a PC or smartphone
3. **Oculus Tracking** It provides room-scale tracking without external sensors.
4. **Audio:** Oculus Quest has positional audio built directly into the headset, so you can hear your teammates.
5. **Two touch controllers:** Easily transport your hands and gesture right into the scene.
6. **Play inbounds (Guardian)**: the virtual barrier for play space. If you go outside of the Guardian's wall and the headset's cameras will activate its passthrough features and allow you to see the real world in black and white.

An all-in-one system built for virtual reality.

- The headset weight 571 g (about 1.25 pound)
- The battery life is around 2–3 hours
- 2,880 x 1,600 resolution (1,440 x 1,600 per-eye)
- Cost: US $600-800

Microsoft Hololens

SWOT Analysis

S

- Mixed Reality: people can Interact with the physical things
- Vivid: Can be layered with real world objects
- Safe in the sense that users can see the real world environment

W

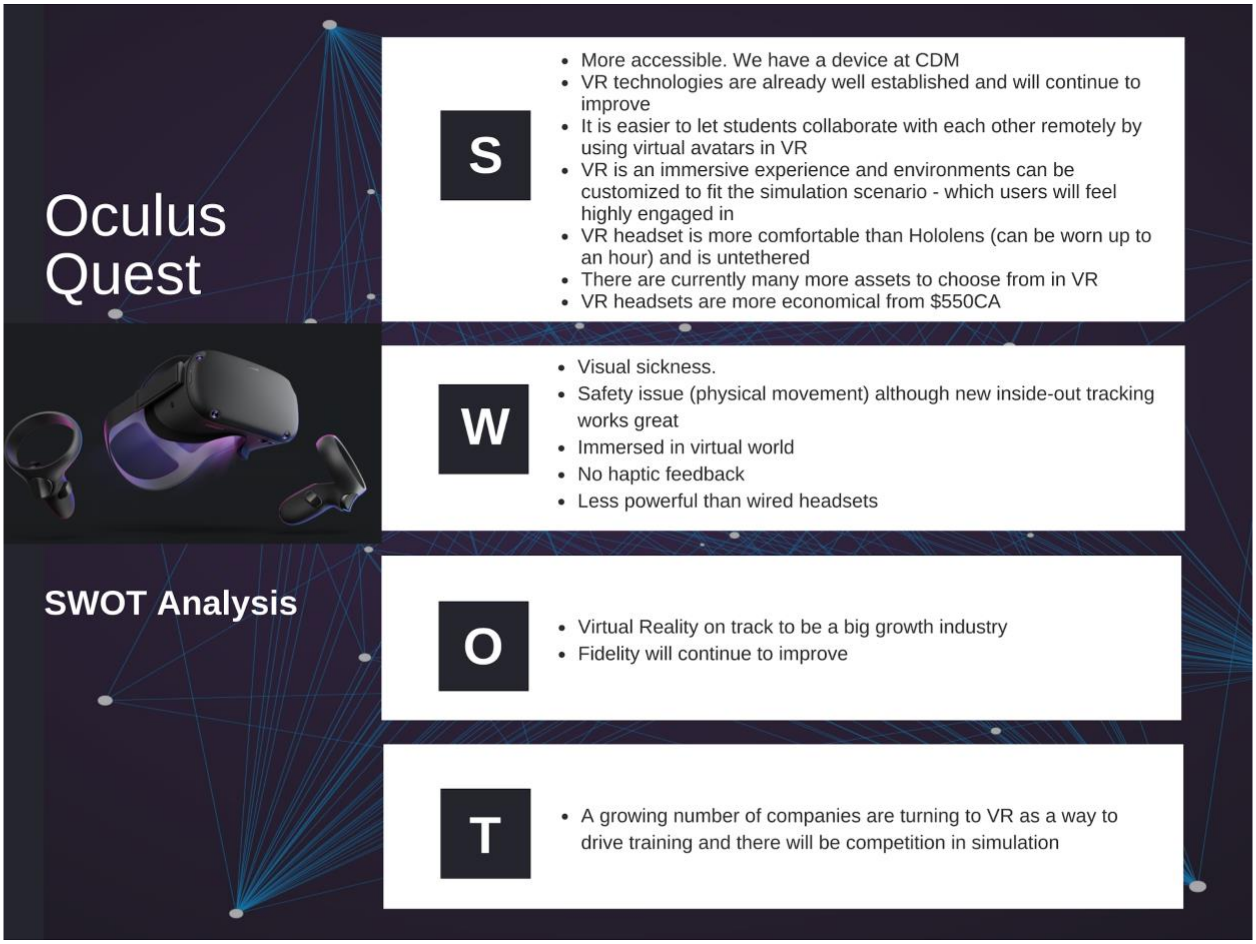
- Hololens is still in its development stage; many kinks have not yet been worked out.
- Hard to share the environment with other users
- Has limited gestures (actions to interact)
- Hololens is heavy and uncomfortable
- We only have access to one Hololens at the CDM
- The headset is pricey and runs around $3500CA

O

- Hololens is a very new and upcoming technology. Creating a simulator with this technology will be like breaking new ground

T

- Because this technology is not fully developed, it's unknown if the product is here to stay or if it will become more widely used.



Research:

Technical research VR and AR

Virtual Reality is becoming more mainstream and has been transforming the gaming and entertainment industry in particular; however, is now starting to revolutionize other industries such as healthcare, retail and education. (BOSS Editorial Team)

Tele-simulation

Tele-simulation allows for the education, training, and/or assessment of learners at an off-site location, eliminating the distance and time barriers for educational delivery. Currently, most of the tele-simulation training is held through 2D web conferencing with aid of webcams and screen sharing software (project brief). “Tele-simulation allows the benefits of simulation to extend beyond the walls of a simulation center and is particularly useful where there are distance limitations that preclude effective/efficient instruction, time constraints that make travel to learner or instructor site impractical, or a lack of available educators with specific content expertise.” (McCoy, Sayegh, Alrabah, & Yarris, 2017) “Implementing tele-simulation into an educational curriculum requires (at a minimum) resources that include, but are not limited to, simulation resources (ranging from simple procedural task trainers to high-fidelity mannequins or standardized patients), telecommunication equipment that allows the capture and transmission of audio/visual data (can range from a simple smartphone, computer, or Web camera, to sophisticated audio/visual equipment within simulation centers), an Internet connection, and software that has teleconferencing capabilities." (McCoy, Sayegh, Alrabah, & Yarris, 2017) "Tele simulation differs from tele-mentoring or tele-conferencing because it actually connects two simulators in different physical locations, allowing teacher and student to see, but not control, what the other is doing in real time" (Mikrogianakis, et al., 2011)

Medical Simulation

"Simulation is a generic term that refers to an artificial representation of a real-world process to achieve educational goals through experiential learning." (Abdulmohsen, 2010)

Medical simulation has increased exponentially over the past two decades for reasons such as an increased focus on patient care and quality, reduction in health care costs through improvement of competencies and better learning outcomes for medical students.

A John Hopkins study claims that more than 250,000 people in the U.S. die annually from medical errors. (John Hopkins Medicine, 2016) This is the third leading cause of death in the US. With a statistic like this, it is no wonder that the need for improved education is a priority. Simulation can deepen learning engagement by providing replicated clinical scenarios that are immersive and experiential. "It is a powerful learning tool to help the modern healthcare professional achieve higher levels of competence and safer care" (Aggarwal, et al., 2010)

The use of simulators allows trainees to practice their skills in a risk-free environment. Giving them a chance to master their techniques in a life-like scenario improves their reliability to make the right decisions in real life – which positively impacts patient safety and health.

History of Simulation

Aviation and aerospace industries have been using simulation as a teaching tool for many years. They are now widely used across many industries; especially in higher risk professions and disciplines. Medical simulation training can be traced back to the 1960's and early 1970's where a computer enhanced manikin was able to reproduce symptoms of cardiac disease. A study of the cardiology patient simulator concluded that fourth year students who used the simulation were better skills than their counterparts who were trained traditionally.

In 1980 the use of manikin simulators spread to anesthesiology and a realistic environment were mimicked to improved training. (Jones, Passos-Neto, & Braghiroli, 2015)

Today, high-fidelity mannequins have been developed with wireless technology that can breathe, dilate their pupils, and experience arrhythmia. Mannequins are becoming lifelike and can provide trainees with an opportunity to monitor vitals, give injections and insert tubes. Instructors are able to manipulate the mannequins; adjusting their vitals, prompting the mannequin to move, speak, groan in pain, cry, sweat, change respiratory rates etc…however; as one can imagine, these mannequins are very costly.

Recently even more realistic environments have been introduced with the development of VR simulation. Being able to create a life-like scenario in a hospital… real overcoming the expected variability of real scenarios in a hospital setting

The importance of simulation

Simulators serve as a tool that helps trainees with clinical experience. The process of practicing in a simulated environment allows for many different scenarios to be carried out for individuals and teams. Sessions can be video-taped and played back to trainees for feedback and debriefing.

Competition

Sim X:

http://www.simxar.com

SimX is a simulation software founded by Physicians in training at Stanford, UCSF, and UCLA, now made up of physicians, health technology experts, and programmers from some of the best institutions in the USA. Sim X flaunts itself as a software that replaces simulation mannequins with a customizable, high-definition, 3D virtual patient that can be projected in any environment that a modern video game can replicate. The company designs their product so it can be used across all major VR and AR platforms.

Oxford Medical Simulation:

http://oxfordmedicalsimulation.com/

Oxford Medical Simulation delivers award-winning medical simulation using virtual reality. The company uses Oculus VR headsets where learners are immersed in virtual scenarios with fully interactive acutely unwell patients. The environment, patient and team are interactive; with the ability to communicate. Users receive feedback, performance metrics and a debrief after the training. OMS uses built in artificial intelligence to drive patient behaviour, adaptive communication, dynamic physiology to deliver experience that feels real. The big difference from VCS is that learners can use the system without an instructor. Their system is customizable and allows institutions to build learning packages around the scenarios.

Ghost Productions:

https://ghostproductions.com/

Using the Oculus Rift, Ghost Productions, develops virtual reality surgical simulations for medical training. The training accommodates multiple users. The company was formed in 1998 and specializes in medical simulations. They are recognized as a leading medical animation and interactive media company.

Target User

The health of a country's people depends, in part, upon the competency of its physicians. In developing nations, challenges include minimal library, technological, and financial resources. Many curriculums do not have the means to train students in applied settings. Medical education is limited by few structured activities, geographical barriers, practice demands, and a lack of library and technological resources. (Bannister, S)

VCS is aimed at medical students in developing countries as well as resource-limited and remote areas and expert medical instructors who would facilitate the training sessions. Because it is directed towards improving medical student's education it therefore should be adopted and implemented by the medical institutions themselves. (See User Personas in UX Design section page 27)

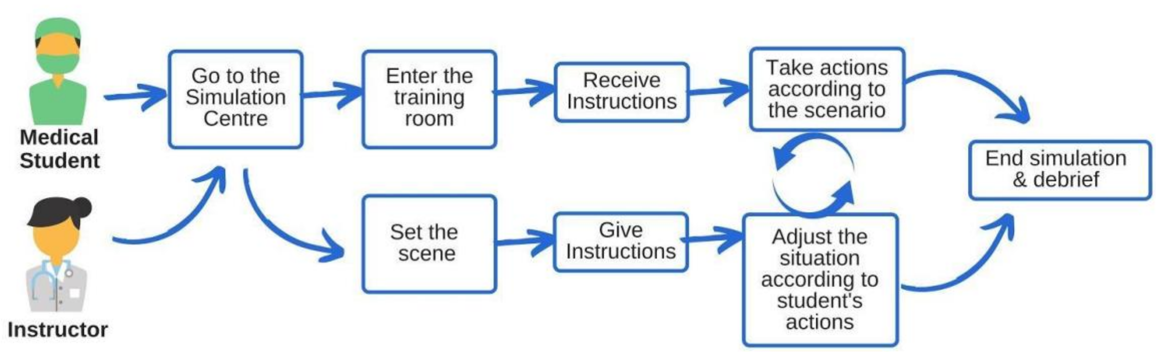
Our Design Process

Site visit

We visited the VGH (Vancouver General Hospital) Simulation Center to understand how clinical simulation training works currently. Right now it is all a physical process. The students and instructors need to be in the same location. The instructor will remain in a small room behind a one-way mirror and use a dedicated software tool to control the high-fi mannequin and vitals. Students take action according to the situation. There are monitors to record the process of training in the room. Instructors will show the recording video and review the process with the students after the training session is complete. The simulation center is used for high-quality medical simulation training, however; in developing countries, there are fewer simulation centers due to financial constraints.

User Journey

We analyzed the normal steps that the medical students take to participate in simulation training and created a user journey map. According to the journey map, we decided to focus on designing the training itself, implementing it in a VR environment and allowing the instructors to control the simulation from a PC.



Scope

The minimum viable product will be a proof of concept of a VR product where one student can enter a virtual clinical environment and participate in a medical simulation training. Simultaneously an instructor can manipulate the vitals and tools in the virtual environment from a desktop/laptop and watch a real-time live stream of the VR scenario.

The proof of concept will include the following features:

- **Programming to achieve basic functionality:** telecommunication, tele-control of the vitals and tools in VR environment
- **3D assets & environment:** mannequin, trauma bay environment, essential equipment
- **User interface:** control panel and onboarding instruction *Only the control panel will have coded functionalities. The onboarding and user journey prior to the scenario will be envisioned and documented but not fully developed.
- **Documentation:** Research, project description, constraints, technical requirements, and future development plans.

Constraints

Budget:
Due to the short development period, the need for simulating the real environment, and the price of high-quality 3D models the team budget may not be sufficient enough to support.

Time:
In general, the development cycle is only 12 weeks, which is a big challenge for the team to build a minimum viable prototype. In addition, the deadline for the delivery has been pushed ahead one week. The client has expressed a need for the main functions to be finished early so it can be presented at the ACS Summit on March 12th. Sticking to these early deadlines is a challenge.

Lack of medical knowledge:
Since the project is for simulating the environment and process of clinical training, the team needs to spend more time on research and learn the professional knowledge, as well as get familiar with terminology.

Oculus Quest:

- **Hardware performance:** As a standalone VR headset, Oculus Quest uses Qualcomm Snapdragon 835 chips as CPU in order to make it portable (it can be considered as an Android phone). But it makes Quest unable to run complex 3D environments, otherwise it will cause rendering latency which can lead to view sickness or dizziness. If connecting Quest to PC through Oculus Link (a USB 3.0 cable, which allows the device to work tethered to a PC via a regular USB type C cable and run PC VR games, including both Oculus and Steam VR games), the problem will be solved but it sacrifices the portability.

- **View sickness:** Except the reason above, VR can still cause this problem to a specific group of people who are sensitive to the low refresh rate, frames per second (FPS), lack sense of direction, etc.
- **Wearing time:** Oculus Quest weighs 571 g, which is not good for long-time wearing.
- **Safety-> less movement:** Although the Quest offers walk through function, which can show the real environment through the cameras when the user cross over the play area, it's still important to narrow down the movement requirement for the safety issue

Solution

Overview

VCS is a proof of concept prototype of virtual clinical simulation training software. The user interface for both the student and instructor was designed to replicate a simulation session that would be carried out in a traditional simulation centre. In simulation centres, sessions are run with the use of physical equipment and tools, a physical mannequin and a vital monitor controlled by an instructor using desktop computer software. The instructor is present, watching the students perform in person, or from behind a one way window. VCS has taken that experience to the virtual world, demonstrating what actions, features and functions are possible to realize in a virtual simulator.

VCS was designed around a specific clinical scenario of a young male patient sustaining a motor vehicle crash suffering with hypotensive shock. In the scenario, the student is expected to do a typical patient assessment; asking the patient how they are, monitoring their vitals and conducting a physical assessment. Upon that, discovering that the patient has suffered trauma to his pelvic region.

The environment mirrors that of a standard Trauma Bay, and there are tools and equipment that are present in the environment, or can be ordered verbally by the student. Only specific tools and equipment necessary to carry out a training session pertaining to this clinical scenario were modeled and programmed.

Agile Statement

FOR	Medical students in resource-limited areas
WHO	Lack access to traditional simulation centres due to cost and distance barriers
VCS IS A	Virtual Reality Clinical Simulation Solution
THAT	Gives students an opportunity to practice their skills in a life-like scenario and risk-free environment with the guidance of professional medical instructors
UNLIKE	Traditional Simulation Centres that cost hundreds of thousands of dollars and are only accessible in urban centres
VCS	Is a cost effective solution that will give students access to simulation and quality instruction through a virtual headset

Key Features

Tele-presence: So long as there is internet access, the instructor can be involved remotely to teach practical skills. Instructors and trainees can communicate with one another in real time and the instructor can see inside the virtual simulator from his/her desktop computer.

Interactive: There are a range of available controls in the instructor control panel that allow the user to modify the virtual environment's default characteristics. The user can edit the numerical field associated with the vitals, can place objects in the environment, can talk as if they were the patient using a hold and press button that activates the patient's mouth movements.

Realistic Environment: high fidelity custom environment that mimics that of a fully stocked trauma bay and live vital monitor. Animated patient that breathes, has a rising and falling chest, blinks, and can talk.

User Friendly: Students go through a detailed onboarding process that instructs them how to interact with the controllers in the case they have never used VR. The tutorial demonstrates how to grab items, move in the environment and exit out of the program. Instructors, likewise, have an intuitive user interface that includes a help button which provides guidelines on the different features and functions. From the interactive control panel, instructors can manipulate the VR scenario with ease.

Pre -programmed Scenario: As an example of what is possible a custom scenario was mapped out and programmed into the environment. All environmental objects and tools were either custom-made or customized to fit the scenario. Medical tools and equipment that would be used in the specific training session were set into the control panel.

Calendar: Schedule training sessions with students on a dedicated day and time. Each time a new session is scheduled a unique code is generated.

Detailed Feature List

Student Trainee Onboarding:

- Welcome screen
- Enter unique passcode
- Enter name
- Select role
- VR hand instructions:
    - Grabbing items
    - Cancel / go back
    - Moving in the environment
- Skip hand instructions (optional)
- Enter environment
- See scenario description in text

Virtual Environment:

- A realistic trauma bay inclusive with the following objects:
    - Bed
    - Crash-cart
    - Defibrillator on top of crash cart
    - Tray table
    - Screen monitor x 2
    - Stethoscope
    - Oxygen mask and tube
    - IV pole and fluid bags
    - Blood pole and blood bags
    - Pelvis Brace
    - Blood Work results
    - Picture of X-rays
    - C Collar
    - Vital monitor with numbers and graphs that can be updated in real time
    - Vital Graphs
- Realistic sounds
    - Heart rate beeping

    - Background noise of a hospital
    - Patient breathing – when stethoscope is placed on chest
- A realistic patient that exhibits some basic animation to demonstrate he is alive
    - Blinking
    - Mouth moving
    - Chest rising and falling
- The ability for the trainee to move freely through the environment
- The ability to pick up stethoscope and place it on patient's heart to hear heartbeat and place the stethoscope down anywhere
- 2-way audio (the trainee can hear the instructor clearly) and communicate to instructor
- Environmental sounds: heartbeat when triggered and monitor beeping
- A monitor of vitals that can be updated in real-time with animated graphs. Number colour changes to red when threshold is reached
- The ability to zoom in on bloodwork, x-rays and gragraphs

Interactive Control Panel:

- Instructor Login
- Enter unique passcode
- View live stream of VR environment
- View patient bio and scenario description
- Change vital numbers
    - Blood Pressure
    - Heart Rate
    - Respiratory Rate
    - Oxygen Saturation
    - Body Temp
    - ECG
- Place objects:
    - IV fluid on poles with tube connected to arm
    - Blood on poles with tube connected to arm
    - O2 Mask on face
    - Pelvis brace secured around patient's hips
    - C-Collar on patient's neck
    - Bloodwork appears on monitor
    - X-ray appears on monitor
- 2-way audio enabled
- Mute button
- Activate patient talking animation button
- Start simulation
- Record live stream

Value Proposition

Optimal Learning

VR provides students with an immersive and engaging opportunity to learn and practice. Complementary to traditional education, virtual simulation training plays an important role to improve learning and knowledge retention. Practicing in a controlled environment eliminates risk, liability, and injury which can result in superior skill building and improved quality of care.

Tele-Instruction
Educators responsible for evaluating and teaching medical students no longer need to physically present to assess students. With off-site access through the use of internet, audio and microphones, instructors and students can tele-communicate.

Replicated life-like scenarios
VCS provides a realistic virtual environment with high fidelity customized objects, tools, equipment and a patient that allows users to learn and test in a real-life like scenario without consequences.

Accessibility
VCS can be used anywhere at any time. Barriers of distance, cost and personnel are lessened because students can access the virtual scenario by simply putting on a headset. An Oculus Quest headset values around $550 CA. With this model of delivery, access is affordable.

Multiplayer
In the long-term, VCS is on track to accommodate multiple users at once in the VR environment. This would reduce the amount of time an instructor would have to put into a single training and provide an opportunity for group learning – similar to real life simulation where training is often carried out in a group.

Team Process:

Stakeholders

Client Dr. Omamah Almousa	Will contribute to the project by advising the team and giving feedback. Interested in having the team develop a demonstrable proof of concept and publishing a paper. Interested in presenting the prototype at The Annual ACS Surgical Simulation Summit.
Team Inter-Vein Meg Dimma, Ruby Zhang, Arden Allen, Parastou Heidari,	Management, planning and execution of a working VR clinical tele-simulation prototype. Dedicated to the project for the purpose of building a quality proof of concept and contributing to the advancement of health technologies. Interested in fulfilling the client's needs and the academic requirements for the project.

Leo Chen, Emily Yao	
Faculty Supervisor Robyn Sussel	Advises the team over the course of the project. Interested in seeing the team succeed and for approving the academic requirements of the project.
The CDM	Supplies the workspace for the team. Interested in seeing the team succeed and for approving the academic requirements of the project.

Team Roles and Responsibilities

Meg	Project Manager	Client Communicator Schedule team meetings and keep each member updated on plans Responsible for team progress and staying on timeline Lead sprint exercises Facilitate meetings and create agendas Lead weekly retrospectives Documentation lead
Ruby	Project Owner & UX Lead	Prioritize product features and scope User persona Wireframe design User experience testing and analysis
Parastou	UX Designer	Branding Storyboarding User Journey Applying 2D design to wireframes Formatting
Leo	3D Modeller	3D modeling Asset research Object placement/rotation Shape modification and scaling Spatial management Lighting & texture Rigging
Emily	Lead Developer	Investigate technical solutions Collaborate with team members in designing solution structure Define development tasks/ subtasks and estimate timeline

		Implement development tasks Collaborate with Leo to develop VR environment Collaborate with Arden to implement functionality into control panel Provide Technical documentation
Arden	Developer	Investigate technical solutions Collaborate with team members in designing solution structure Collaborate with Emily to implement programming tasks Provide Technical documentation
Robyn Sussel	Faculty Advisor	Provide Team Guidance

Communication Plan

WhatsApp	Team Communication	For brief messaging within the team when offsite For quick information and reminders
Slack	Team & Faculty advisor	All team communication
Google Drive	Team Documents	All team documentation will be stored on the Google Drive folder
Github	Development team	To back up and store the team's source code, and collaboration between team members
GitKraken	Development and Modeller	Version control
In person meetings and email	Development team, Faculty advisor & client	To receive feedback on the team's deliverables for the sprint and brainstorm on ideas to further the product's development
Slack #progress	Team, Faculty Advisor & Client	A separate slack group dedicated to keeping our team and client updated with our progress

Assumptions

Assumptions	**Justifications**
The project deliverable will be a proof-of-concept prototype and not a complete useable product	The intended purpose of this project is to demonstrate what is possible and how clinical tele-simulation can be delivered in VR which can remove barriers to access.
The prototype used in this product is expected to be further developed and applied to other scenarios for clinical simulation	The team will build a working prototype that demonstrates the feasibility of the concept and potential for future developments. Not all desired features can be developed in this term, but will be well documented.

Risk Assessment

Risk	Likelihood	Impact	Mitigation Plan
Product already exists	High	The objective of this concept being "new" or "pioneering the way" is not so	Focus on the accessibility of the product rather than the fact it's already been done.
Oculus Quest is not the perfect technology choice for this product	Medium	The Oculus quest has limitations of bandwidth – meaning that our prototype must make use of a lower-fi environment to compensate for any disorientation.	Surely as technology evolves, the Oculus Quest will adapt to be able to support higher fidelity environments.

Schedule, Milestones & Deliverables

The timeline of this project is intended for continual progress on the project. Due to the nature of the agile approach, the goals outlined below are subject to change. User testing may provide us with new information that could result in iterations that could impact the timeline.

Weeks	Goals	Notes
1	• Intro Meeting	
2	• Research • Storyboard Prototype • Team Charter	**Prototype 1:** Storyboard view from Student
3	• VGH Simulation Centre Visit • Control Panel Sprint	**Prototype 2**: Storyboard of Instructor
4	• Key features/scope • Technical research	**Prototype 3**: Control Panel
5	• Low Fidelity Environment Setting (trauma bay and room assets) • Wireframe Control Panel • Discovery Tree Map	User test UI control panel Clarify Scope
6	• Environment progress • Wireframe Control Panel Finalized • Student Wireframe	User test student VR onboarding and interface
7	• Environment progress • Wireframe Control Panel + add design	User test environment
8	• Environment progress • Student Interface + add design	
9	• Environment (Trauma bay and room + assets) • Control Panel Coded	User test functionality of Control Panel+ VR interaction
10	• Mannequin rigging	

	• User journey finalized	
11	• Final Prototype presentation: last call for changes • Product Video	
12	• Final product delivery + required documentation	April 2nd Final Product to Omamah
13	• Final product + full documentation inclusive with team process, future development, technical documentation • 2 page individual reflection • Peer review due	April 6
14	• Final Presentation	April 8th Final Presentation

Sprint Log

Over the course of the 13 weeks Team Inter-Vein conducted eight design sprints. The sprints were typically composed of all team members led by the project manager or product owner. The purpose of the sprints was to understand as a team where we were headed all the while keeping our main objectives and problem in mind. They often included mapping out user journeys to predict pain points and suggesting features and functionalities that would simplify the user experience. They often required gathering inspiration and having each team member individually develop their vision and communicate it with the team. Once we had a working prototype, our sprints turned into user test ideation. These were very useful for prioritizing workflow and determining what components had to be completed prior to testing.

The design sprints were colossal in helping us achieve a working proof of concept in a short 13-week period. They helped to minimize the time we had to spend meeting with each other to clarify goals, they allowed us to solve problems together, they kept our momentum pushing forward and they gave us a chance to test our assumptions. Above all the sprints provided an opportunity for each team member to voice their opinion of the direction they wished to see our prototype go. It certainly proved that many minds together are greater than one.

Sprint #	Title	Goals	Process & Outcome
Sprint #1 Week 2 Jan 13	**Storyboard #1: The Student Journey**	Ideate the user journey of the medical trainee who will be using the VR headset to experience a clinical simulation. Align the team on a common visualization of the student user journey.	Each team member sketched how the student user would flow through the experience of using a VR headset, (as a first-time user) to enter the VR simulator. Sketches were timeboxed for 20 mins. Each team member presented their sketch. Team members voted on components that they felt were useful. A final storyboard was created, comprised of the agreed upon components.

			UI lead created a finalized storyboard *__See Appendix A5 to view Storyboard #1 The Student Journey__
Sprint #2 Week 3 Jan 20	**Storyboard #2: The Instructor Journey**	Ideate the user journey of the instructor who will be using a desktop computer to manipulate the virtual scenario according to the student's actions and reactions. Base it on the existing instructor software that we saw at the VGH simulation centre. Align the team on a common visualization of the instructor user journey.	Each team member sketched how the instructor would flow through a PC based application. From logging in, to scheduling a session with students, creating new scenarios and entering into the control panel. Sketches were timeboxed for 20 mins. Each team member presented their sketch. Team members voted on components that they felt were useful. A final storyboard was created, comprised of the agreed upon components. UI lead created a finalized storyboard ***See appendix section A5 to view Storyboard #2 The Student Journey**
Sprint #3 Week 4 Jan 27	**Control Panel Wireframe for User Test in week 5**	Build a wireframe prototype of the control panel to test users for feedback. Determine if the wireframe is clear and intuitive.	Based on our Storyboard #2, our UX designer mocked up a wireframe in Sketch. Tasks for User Test: ● Sign in to the account and create a new training. ● Select the preset trauma case ● Input specific date and time ● Start simulation ● Complete specific tasks in the control panel such as muting the microphone, changing vital numbers, and placing tools.
Sprint #4 Week 5 Feb 3	**Product Name Brainstorm**	To come up with a professional, unique and appropriate name for our product.	3 team members participated in the Product Name Sprint. Our UI lead wrote down a list of words that were directly associated with our product to keep our brainstorm on theme. Then the team members spent 20 mins writing down their ideas for product names.

			The entire team participated in voting for the most suitable name and presented the top 3 names to our client. The three names were: 1) Medisim 2) VCS (Virtual Clinical Simulation) 3) VR Tele-Sim Our client selected VCS (Virtual Clinical Simulation) as the chosen product name.
Sprint #5 **Week 8** **Feb 24**	**Outline for Student Journey User Test** **Mar 5**	To validate the Student Journey & VR environment Test Task Completion ● Is it clear? ● Are there obstacles? Test User Experience	To outline the user test, the team had to come together to determine all components necessary to meet our goal. We time-boxed 20 mins to determine our test plan and then outlined specific components that needed to be accomplished before user testing. **Tasks for user test** ● Enter the simulation (test the onboarding process and clarity of VR hand instructions) ● Interact with patient and stethoscope, listen to breathing and view chest animation ● Order IV Fluid ● Hear instructions/audio **In order to test the following components must be completed:** **Programming:** ● Complete stethoscope/breathing interaction ● Make IV fluid appear ● Onboarding ● Integrate animation **Modeling:** ● Chest animation ● IV Fluid on Pole **UX:** ● Finish Student Journey Wireframes **UI:** ● Apply UI to wireframes

Sprint #6 Week 9 Mar 2	**Outline for Instructor Control Panel User Test Mar 12**	To validate the Instructor Control Panel
		
		Test Task Completion
		● Is it clear?
		● Are there obstacles?
		
		Test User Experience
			To outline the user test, the team had to come together to determine all components necessary to meet our goal. We time-boxed 20 mins to determine our test plan and then outlined specific components that needed to be accomplished before user testing.
			
			User Test Tasks:
			● Login to control panel
			● Have testers manipulate the environment with the control panel
			    ○ Establish an audio connection with VR user
			    ○ Change vitals
			    ○ Place items
			    ○ Talk as the patient and activate mouth animation
			    ○ Mute the speaker
			    ○ Adjust the volume
			
			In order to test the following components must be completed:
			
			Programming:
			● All buttons on control panel coded and functional
			● Implement a live monitor in VR that updates when vital numbers change and have vitals change colours when they reach a certain threshold
			● All 7 objects can appear and disappear when activated
			    ○ Iv fluid
			    ○ Blood
			    ○ 02 mask on face
			    ○ C-collar on neck
			    ○ Pelvis Brace
			    ○ Bloodwork
			    ○ XRay
			● Mute button working
			● Facial animation implemented

			Modeling: ● Finish the design and placement of all interactive objects: ○ Iv fluid ○ Blood ○ 02 mask on face ○ C-collar on neck ○ Pelvis Brace ○ Bloodwork ○ XRay ● Update final environment ● Patient facial animation **UX:** ● Create task instructions ● Create post test survey and interview questions **UI:** ● Implement a new button for activating patient facial animation into control panel interface ● Complete logo Design
Sprint #7 Week 10 Mar 9	**Outline for VR Environment and Instructor Control Panel User Test Mar 20**	To validate the speed, connection and accuracy between control panel and VR environment ● Test Audio connection ● Test both user's experience Test Task Completion ● Is it clear? ● Are there obstacles? *NOTE – this user test was unable to be realized due to COVID -19 and social distancing. The test was instead carried out by 2 team members and our client to test functionality.	To outline the user test, the team had to come together to determine all components necessary to meet our goal. We time-boxed 20 mins to determine our test plan and then outlined specific components that needed to be accomplished before user testing. **User Test Tasks:** **User 1:** ● Login to the Virtual Simulation ● Go through onboarding and VR hand instructions ● Enter Simulation & make audio connection with instructor ● Verbally communicate the changes that are being made in the VR environment and follow instructor's commands

			• Pick up the stethoscope, place on patient chest to hear breathing, put down stethoscope **User 2:** • Login to VCS • Proceed through the instructor dashboard to the Instructor Control Panel • Verify that the student has logged in and establish audio connection • Use the help button to see tips and tricks on how to use the control panel • Start simulation • Change vitals and ask student to verify changes • Place object and ask student to verify changes • Speak on behalf of the patient and verify that patient mouth animation is working • Adjust the live stream viewpoint • Stop simulation and download video **Modeling:** • Finish environment lighting and texture • Complete patient mouth animation • Add tubes that connect to patient arm (just below the elbow) to blood and iv fluid **Programming:** • Add loading bar to student onboarding • Add “students are online” icon to control panel • Change colour of start and stop button in Control Panel • Add help overlay to Control Panel - highlight how the live stream view can be adjusted • Complete interaction of stethoscope & ability to put it down anywhere

			• Incorporate animation and activate mouth animation button in CP • Instructor login and dashboard • Download video for debrief **UI:** • Add final hand instruction (how to move in the environment) to onboarding tutorial • Implement confirmed logo into all UI parts

Sprint #8 Week 11 Mar 16	**Storyboard #3 Promo Video plan**	Ideate a promotional video plan that can be achieved in one week without filming freely (due to the constraints of Covid-19). Incorporate a solid intro that introduces the problem, solution that highlights the features of our product.
		
		Align the team on a common visualization of the promo video.
		
		**NOTE, this sprint was conducted via videoconference due to the constraints of Covid -19
			Before conducting a time-boxed storyboard sprint, each team member researched video inspiration to share with each other to help support their vision and shared it with the team. We talked briefly about how we might convey some ideas before breaking off individually to draw our own individual storyboards.
			
			Sketches were timeboxed for 25 mins. Each team member presented their sketch. Some members sketched drawings on paper, others on a computer program or with a PowerPoint. Team members each had a chance to present their vision and then the team voted on components that they felt were strong. A final storyboard was created, comprised of the agreed upon components.
			
			The outcome was this video outline:
			Intro:
			• Problem and current state of medical simulation
			• Target users
			• Need
			Middle:
			• Our solution: VCS
			• Features and function
			End:
			• Reiterate the major features
			  ○ Tele-simulation
			  ○ Realistic environment
			  ○ Ease of use
			  ○ Multiplayer

			• Final clip of Omamah describing the importance and impact of VCS • Logo animation The UI lead created a finalized storyboard ****See appendix section A5 to view Storyboard #3 VCS Video Storyboard**

UX Design

Overview

This project is about transforming traditional clinical simulation training centers into a VR experience. The objective is to help medical students in resource-limited areas attain higher quality clinical simulation training. It requires a lot of research and analysis of user behavior.

Product Story

Problem:

There is a lack of high-quality medical education resources (specifically clinical simulation training centers) in Sudan.

Nadia Ahmed is a post-graduate medical student. She studies at the University of Khartoum, which is the best medical school in Sudan. She works really hard on her studies because becoming a doctor has always been her dream. She would like to pursue cardiovascular surgery after graduation. Right now, she is taking a course related to this area. The course requires her to participate in simulation training 3 - 4 times a week. She loves simulation training as she thinks it is a great way for her to practice her knowledge and get more familiar with responding to emergencies. However, she is unsatisfied with the low-fi simulation environment. Due to financial reasons, the university's clinical simulation training situation is really poor. There are some dedicated rooms for simulation training but those rooms only have beds, low-fi mannequins, and basic medical equipment.

On the other hand, in a developed country like Canada, there are advanced simulation centers that provide dedicated instructors and high-tech training equipment to medical students for the purpose of getting hands-on practice. These simulation centers are extremely expensive and have limited capacity. But for obvious reasons, Nadia does not have access to this type of training.

Solution:

Virtual Clinical Simulation (VCS) can solve this problem for Nadia. VCS is a VR medical education tool that provides clinical simulation training to medical students around the globe.

Instead of having to physically attend a simulation center, clinical training happens in the virtual world. By simply putting on the VR headset, students enter into a virtual medical environment to participate in a simulated training session. The environment is designed after a real-world medical environment and in the simulation, the patient is even more life-like than a mannequin. VCS also supports multiple students training at the same time. Unlike traditional training centers where the instructor needs to be in the same place as the trainees, VCS allows the instructor and the trainee to be in two different locations. The instructor can use their PC to control the simulation process, see the real-time situation in the VR environment, and communicate with the trainees. This solution eliminates the barriers of distance, time, personnel and financial burdens to benefit medical students in developing countries and rural areas.

In addition, compared to advanced simulation centers that cost millions of dollars, each VR headset only costs hundreds of dollars, which is an economic solution.

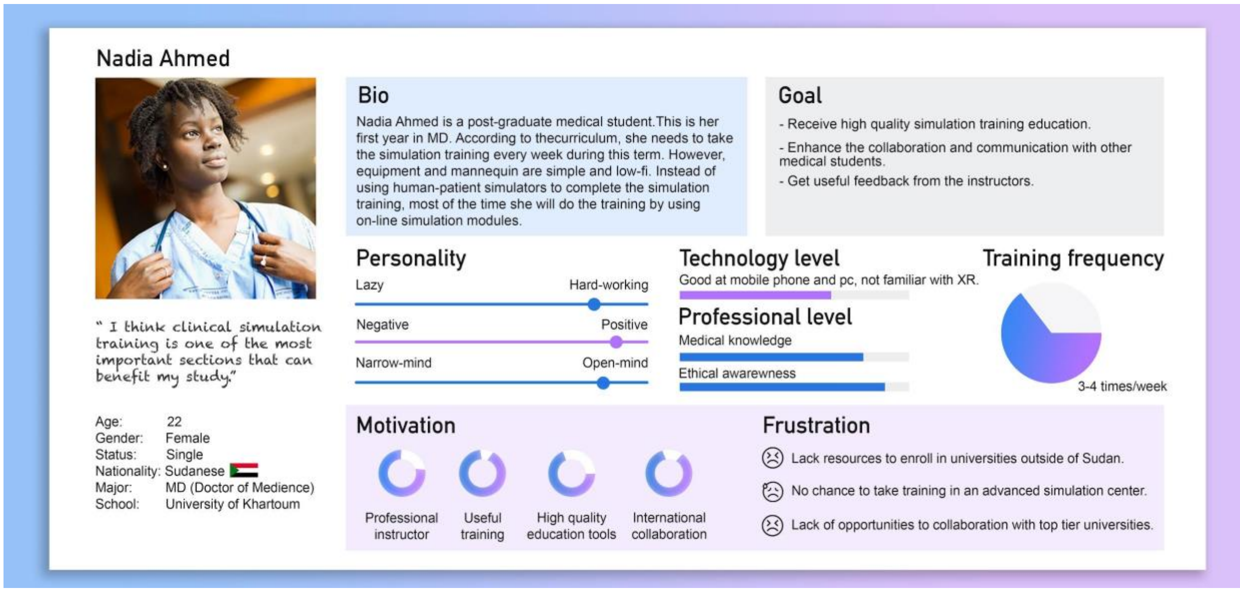
By using VCS, Nadia has the opportunity to access better quality medical training and a chance to receive instruction from top medical practitioners from around the world. Now, she is one step closer to achieving her dream.

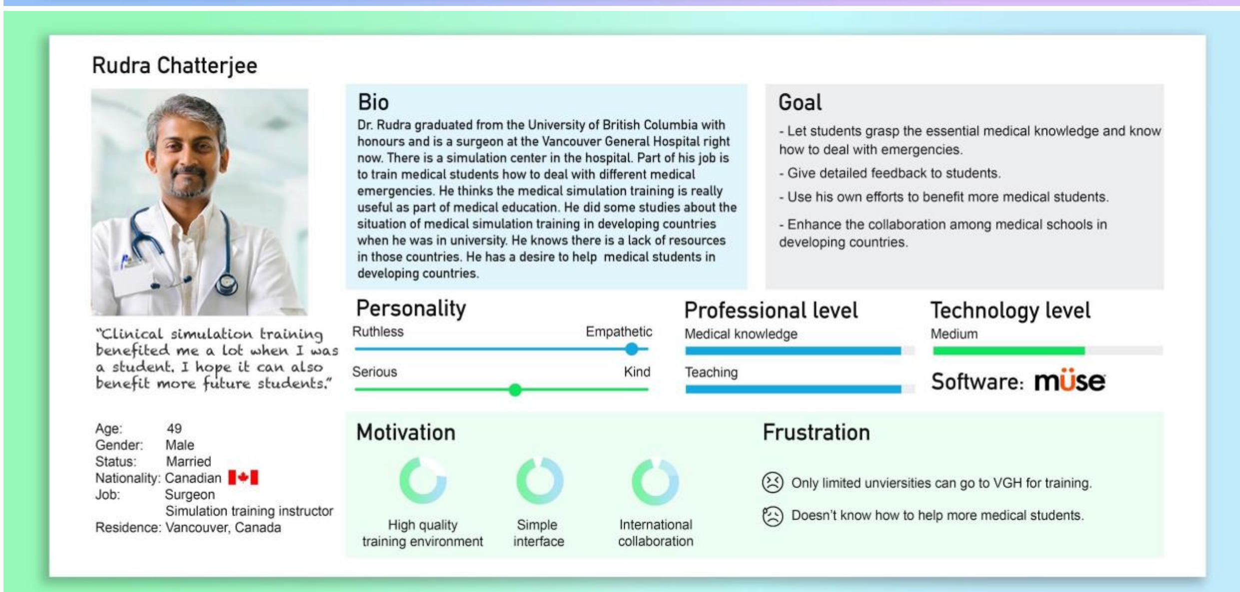
Background

Define the problem:
The quality of clinical simulation training for medical students in developing countries and rural areas is extremely low.

Target User:
We have two types of target users: medical students in developing countries and medical training instructors.

Below are the user persona of these two target users.





Site visits:

We visited the VGH (Vancouver General Hospital) Simulation Center to understand how clinical simulation training works currently. Right now it is all a physical process. The students and instructors need to be in the same location. The instructor remains in a small room behind a one-way mirror and uses a dedicated software tool to control the high-fi mannequin and vitals. Students take action according to the situation. There are monitors to record the process of the training sessio. Instructors will show the recording video and review the process with the students after the training session is complete. The simulation center is used for high-quality medical simulation training, however; in developing countries, there are fewer simulation centers due to financial constraints.

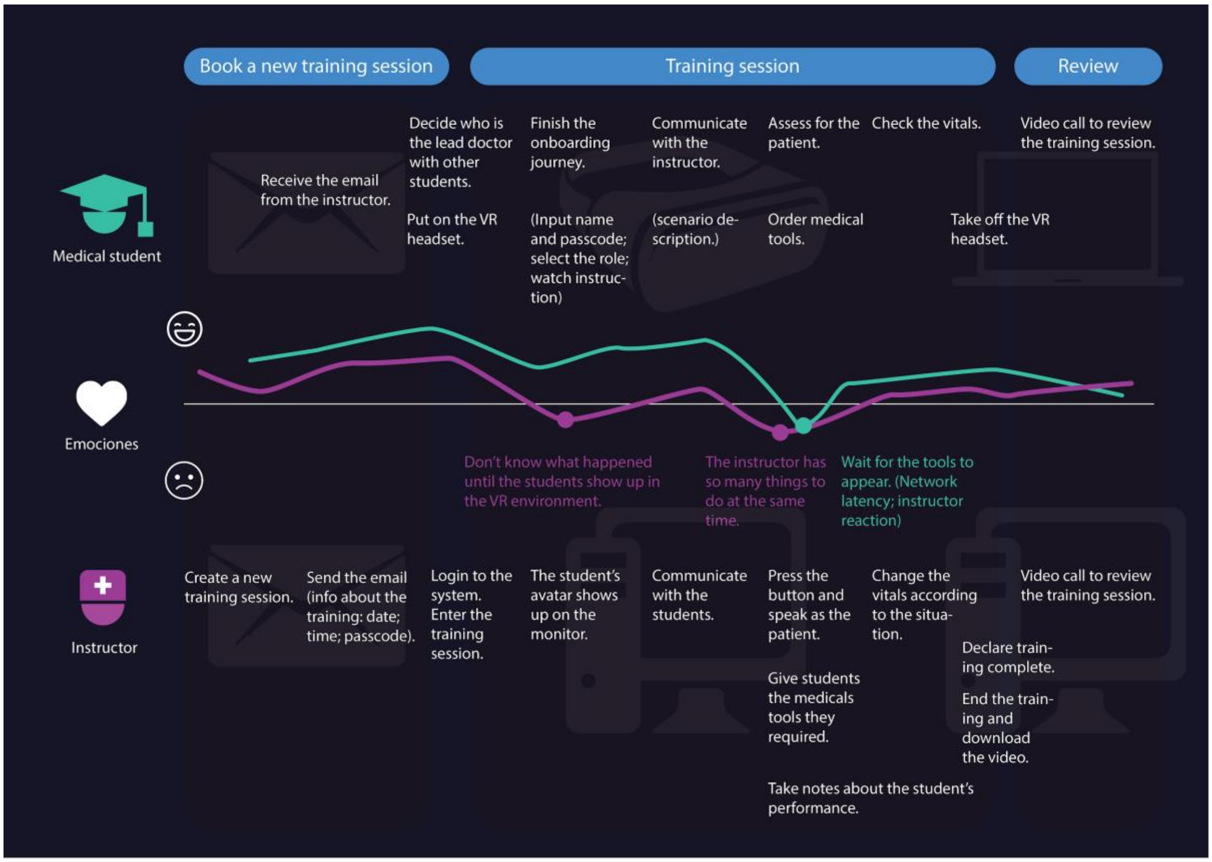
Design Process

User Journey:

We analyzed the normal steps that the medical students take to participate in simulation training and created a user journey map shown earlier in the documentation. According to the journey map, we decided to focus on designing the training itself, implementing it in a VR environment and allowing the instructors to control the simulation from a PC.

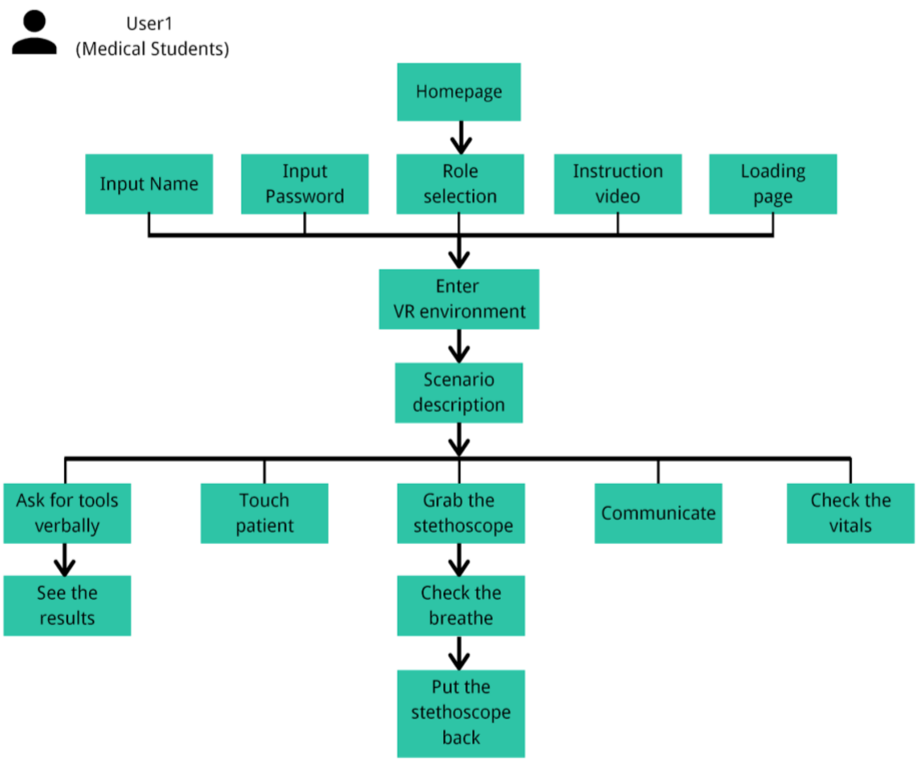
After we determined the design content, we started to design the wireframe. We separated them into two parts which are the instructor's control panel and VR interface.

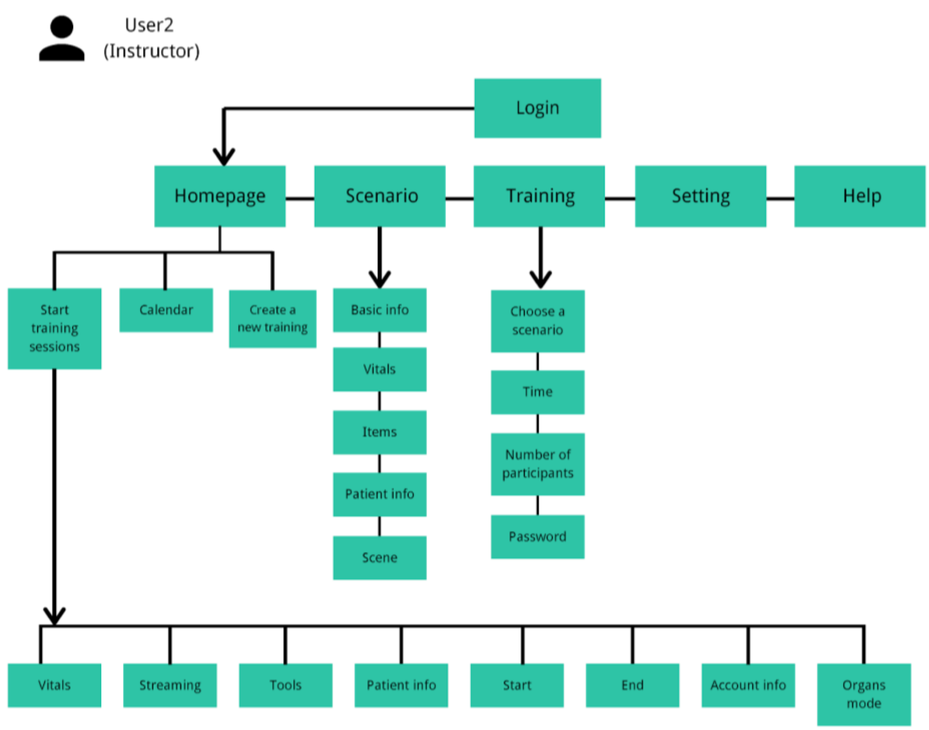
Then we made a user journey for our prototype to understand what functions need to be included and what is the contact point.



User Flow:

Below is the user flow for both users:



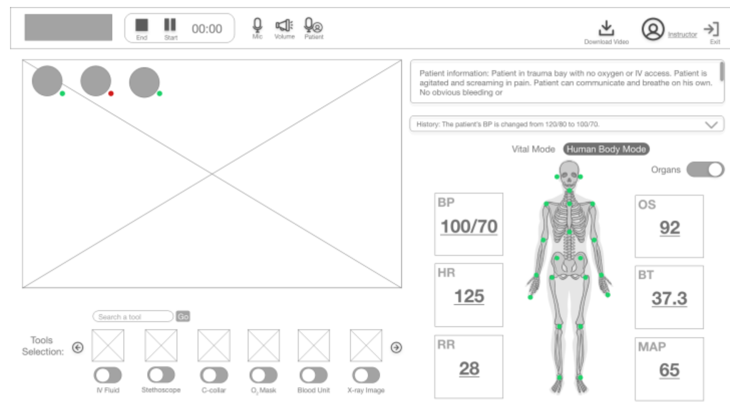


Wireframes:

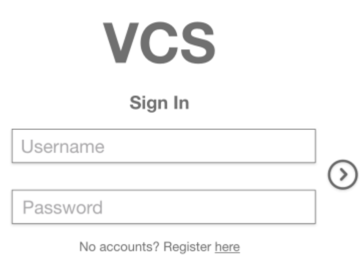
According to the user flow, we designed the wireframe. The inspiration comes from the application used by the VGH Simulation Center right now. Because we want the instructors can know how to use it quickly so we tried to make the interface simple and clear. We have iterated several times according to the user test results. This is part of the final version of the wireframe. For the whole wireframe, please see the appendix.

Control Panel -1

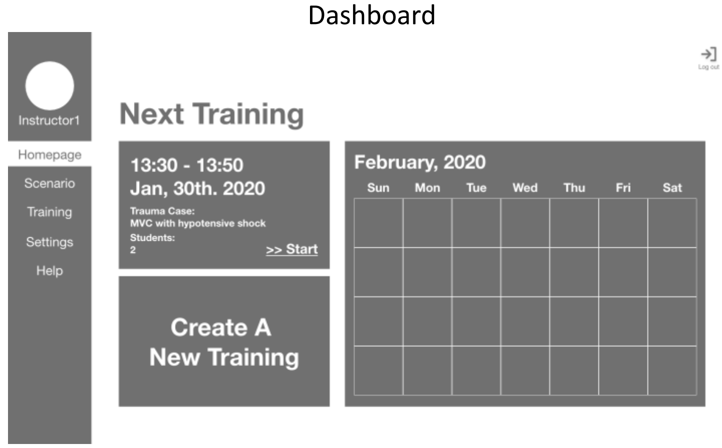
Control Panel - 2



Log In



Dashboard



User Testing

The original plan was five usability tests : control panel wireframe test (twice); VR prototype test; functional control panel test; complete prototype test. However, because of the COVID-19 situation and the university policy, the final test had to be canceled. We only tested the complete prototype with ourselves and our client to uncover some essential changes.

The below form is the four test results and conclusions. All raw materials can be found in the appendix.

No.	Test details	Result	Conclusion
1	This test is about the interface that the training instructors use. We designed the wireframe about the control panel and the basic frame of this application. The goal is to see if this wireframe shows each function clearly and intuitively. Date: Feb 5th, 2020 Location: Project Room 1 Test sample: 10 students *(Survey + Observation)*	● 50% of testers think the user journey is intuitive; 40% of testers are not very determined it is intuitive; 10% of testers think it is not intuitive, he thinks we give too many instructions. ● 90% of testers think our wireframe is easy to understand for most of the parts. ● 50% of testers need to read the words under the icons to help them finish the tasks. ● 80% of tester think changing different modes is the hard part for them. ● 60% of tester think to activate the first tool is the hard part for them. ● According to the observation, 4 people got hesitated when they were asked to end the simulation; 3 people missed the first part of “start the simulation”.	● Use colors to show the ON/OFF situation. (UI) ● Switch the ON/OFF situation to show their current situation. Or change it to another layout. ● Enlarge the “next” icon in “Create a new simulation” part and add text “next”. ● Put the “Organs” button on the same place with the mode switch button. ● Add some explanation on the “start” and “end” button. ● Change the audio connection. ● Add more connections. ● Emphasize some icons and text which are going to be activated in our real product.

2	This test is to verify if the changes from the last test are helpful for users to use the wireframe. And also trying to found other improvements. Date: Feb 12th, 2020 Location: Project Room 1 Test sample: 5 students *(Interview)*	● 100% of users agreed that the wireframe was easy to use. ● 100% of users thought the user journey in this wireframe is intuitive. ● The “start simulation” part is confusing. ● Some words are not accurate. (e.g. Vitals mode; Human body mode; activate)	● Add a search bar on the tool selection area. ● Delete the word on/off and add tools’ names. ● Delete the photo on the patient information area. It is useless information. ● Change the way of starting/ending the training session. ● Change the position of the history information.
3	This test is to test the VR environment that we created. Testers put on the VR headset and finished the tasks that the instructor told them. The goal is to figure out if the VR environment design is intuitive for users to interact. We tested 5 features which are audio instruction; onboarding journey; grab items ; remote control items from the control panel and interact with the patient. Date: Mar 5th, 2020 Location: Classroom B Test sample: 12 students *(Survey + Interview)*	● 80% of the testers have experience using VR. ● The hand instructions are helpful for VR beginners and experts. ● The interactive functions run smoothly. ● The environment is immersive and attractive. ● Nearly 90% of testers didn’t understand the medical terminology. ● Testers don’t know where the stethoscope is. ● Moving is hard.	● Adjust the keyboard’s angle and size. ● Fix the audio system. ● Change the initial position. ● Make the stethoscope can be put back in anywhere. ● Add interactive feedback when things appear in the trauma bay. ● The patient and the bed scale need to be bigger. ● Adjust the environment lighting lighter and warmer. ● Connect the IV tube to the patient ● Change the color of the stethoscope (Red) ● Change the color of the wall and floor (Green).

		● Keyboard & audio system are confusing. ● Lack of feedback in the VR environment when the testers finished tasks.	
4	This test is to test the functionality of the Instructor control panel. Users will log in to the instructor dashboard on the desktop and complete tasks. The goal is to improve the user experience and interface design. Date: Mar 12th, 2020 Location: Project room1 Test sample: 12 students *(Survey)*	● All testers finished the tasks. ● Around 82% of testers thought the control panel is intuitive to use. ● 83.3% of testers heard the audio from the student clearly. ● 90% of testers recognized “VCS” from the logo. ● Most testers think the UI is clear to understand but needs more interaction. ● Nearly 50% of testers mentioned the vitals part need more visual feedback when they changed the numbers.	● Adjust the volume of the communication and ensure both sides can hear each other clearly. ● When the user clicks into the number (on vitals), the numbers delete automatically. ● Make the vital numbers' font-size become bigger when the mouse across them to show that it can be changed. ● Add the pop up “help” button to view instructions of using the control panel. ● Add “the number of participants” icon.
5	This is a non-official user test. We invited our client to be the tester to do the final check of the prototype. Date: Mar 20th, 2020	● The tester was satisfied with the VR environment, tele-control.	● Sound & audio connection– the communication between the instructor and the

	Location: Project room2 Test sample: 1（Our client） *(Interview)*	● The audio connection was not stable. ● The tester thought the way of checking the blood result and x-ray images is not intuitive. ● The shadow of the trainee is annoying.	trainee wasn't working. ● Change the way to expand the images in the VR environment. ● Remove the coffee mug ● Remove the shadow of the trainee.

Constraints

There are some constraints when we were doing the user tests and the results may be affected because of those constraints.

- All the testers are not medical students. Because of lacking the panel to connect with the real medical students in the developing country, we only tested the prototype with the cohort.
- The amount of sample is limited. It is hard to verify if the prototype would be suitable for most of the people who are beginners in VR devices. Because of this, we made many instructions to make sure users can understand how to use it in a short time.
- The prototype is a proof of concept. Due to the limited time and the emergency situation because of the covid-19, the prototype only implements the key features.

Conclusion

After the user tests, we concluded that our clinical simulation training prototype can eliminate distance and cost limitations. To achieve true market readiness so that it can benefit all the medical students in developing countries, we would need to conduct further user tests on real medical students geographically spread out.

Reflection

After the user tests, we learned a lot about the method and strategies of user tests. For each user test, we found some improvements and implemented those improvements into the next user test. We realized there are some key points that need to be considered thoroughly when we prepare for a user test.

- Design the user test journey.
- The instruction for the users is important. We need to think about the testers' knowledge level, habits, and abilities.
- Before test users, we need to run the test by ourselves to make sure everything works well.

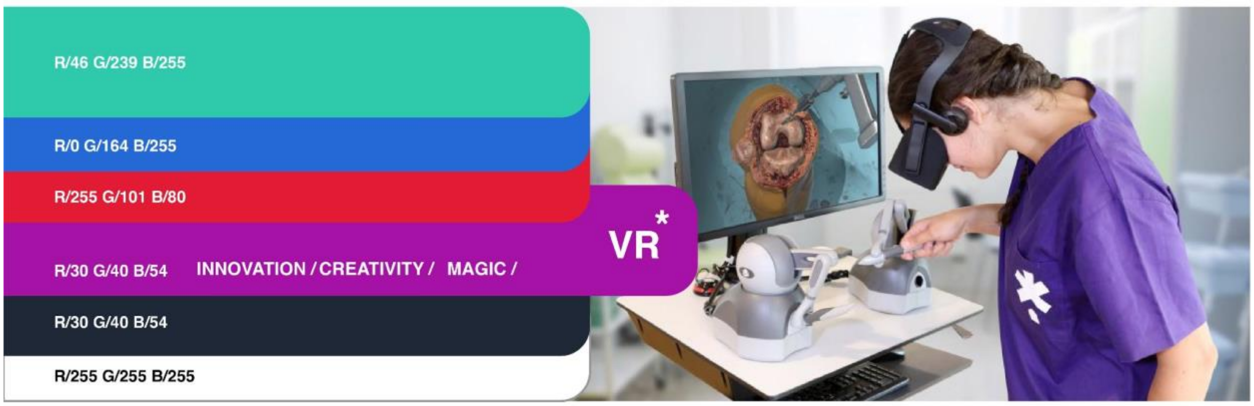
Brand Assets

Style guide

The VCS style guide was designed with extensive research to evaluate what colours and fonts would best be suited for a medical VR technology product.
To view the colour research and mood board, please see appendix A1.

Colour Palette

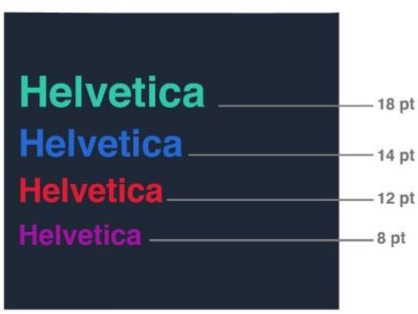
COLOUR PALETTE



*Purple has been added as a complementary colour to the palette to represent VR technology. Research has suggested that purple is the dominant colour among current VR branding.

Font

FONT



Helvetica

Helvetica offers advanced font hinting, expanded characters and modified line thickness and x-height to optimize legibility across VR displays, smartphones, tablets or e-readers. Helvetica eText aids the reader while delivering style, and is particularly well suited to anything on a grid, for example health metrics for virtual eCommerce experiences.

Helvetica Light
AaBbCcDdEeFfGgHhIiJjKkLlMmNnOoP-pQqRrSsTtUuVvWwXxYyZz0123456789

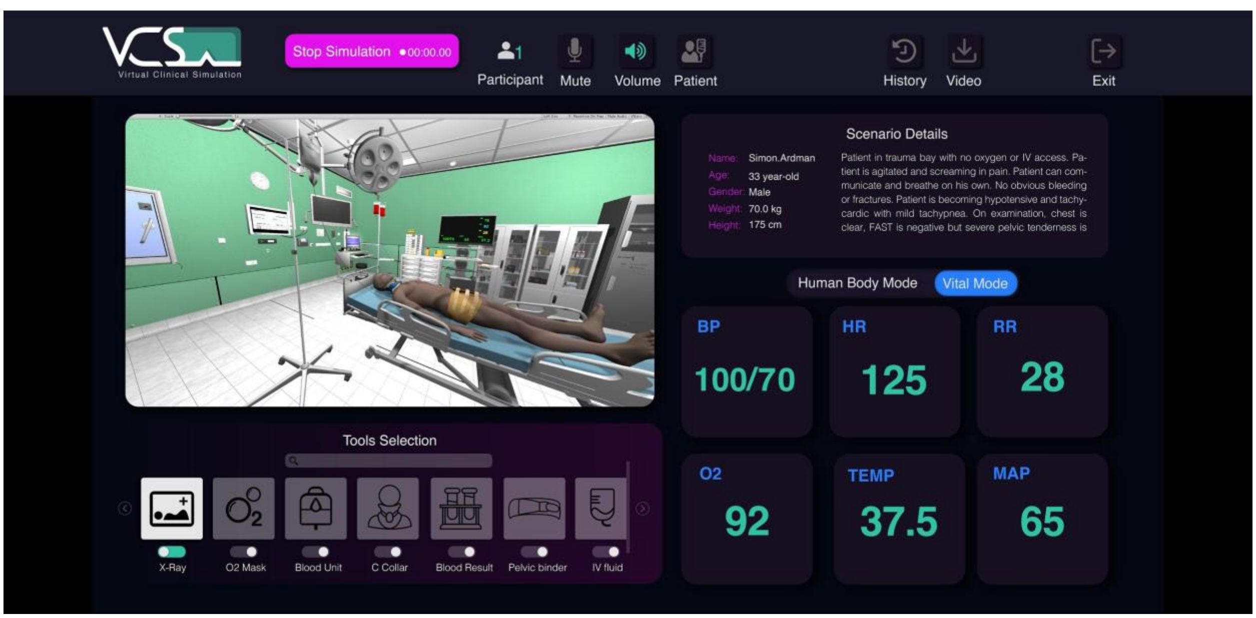
Helvetica Bold
AaBbCcDdEeFfGgHhIiJjKkLlMmNnOoP-pQqRrSsTtUuVvWwXxYyZz0123456789

Logo

To view mock ups of the logo in use, please see appendix section A2

User Interface Design

To view more UI Design, please see appendix section A3



3D Modelling

Overview

The following describes what environmental elements and tools were required for this prototype, the kind of processes necessary and software programs used. The objective was to build an high-fidelity realistic environment and patient.

Patient

High fidelity mannequin/patient

- 20-30 years old male
- Average weight and build
- No obvious bleeding or fractures

Essential 3D objects

- Patient model
- Hospital bed
- Monitor to display the vitals -linked in real time to Instructor Control Panel
- Crash cart (doesn't need to be interactive)
- O2 mask on face (not visible until ordered)
- C-collar on table
- Defibrillator (on top of the crash cart)
- IV bag + pole (no fluids until ordered)
- Blood units & pole (no blood until ordered)
- Pelvis Binder (not visible until ordered)
- Stethoscope (on crash cart)

Form Specification

- 3D Geometric modelling
- Object placement/rotation
- Shape modifications (scaling)
- Spatial constraints & scaling
- Synchronization of multiple objects

3D Rigging:

- Patient chest rise & fall
- Patient blinking
- Patient mouth movement

Software & Plugins:

- Autodesk Maya --Version 2019
- MGear Autorig System (Rigging Plugin for Maya) --Version 2019
- NgSkinTools (Weight painting Plugin for Maya) – Version 1.8.2

- Autodesk 3D Max Studio –Version 2019
- Unity --Version 2019.2.19f1

Technical Documentation

Overview

Virtual Clinical Simulation (VCS) is a composition of two types of client-ends: PC application for instructors and VR application for trainees.

For the former one, instructors can log in to their accounts and check the dashboard to get the information about training sessions. When starting the simulation, it is possible for instructors to observe trainees' actions and give guidance in real-time. Also, they are able to change or interact with the virtual environment (e.g. changing vitals or activating tools), so that when trainees are dealing with the problems, instructors can give them feedback immediately. And in real-life clinical simulation, it is very flexible for instructors to add or change phases based on the situation, so it also meets the requirement of flexibility.

The latter is designed for medical students who are in undergraduate and have limited accessibility to real clinical simulation centers. It offers a realistic 3D trauma bay in order to give them a sense of immersive. Before the simulation, students need to input their name, unique room number and select their roles (lead doctor or doctor) to access the server. Before entering the training, hand instruction will be provided to help them get familiar with the control methods and finish the simulation smoothly. During the training, trainees can interact with specific tools (e.g. grabbing the stethoscope) and talk with instructors to get items for saving the patient's life (like the oxygen mask).

Specification

Hardware requirement

- Oculus Quest
    - Display Type: OLED
    - Display Resolution: 1440 x 1600 per eye
    - Refresh Rate: 72Hz
    - Processor: Snapdragon 835 processor
    - RAM: 4GB
    - Portal: USB Type-C, 3.5mm headphone jack (x2)
    - Weight: 571 grams
- USB TypeC to USB 3.0 cable (for enable Oculus Link)
    - Available options:
      Oculus official accessories

Anker USB TypeC to USB 3.0 cable

Software requirement

- Unity 2019.2.19f1
- Oculus App Version 15.0.0.200.456 (15.0.0.200.456)
- Oculus mobile application

Plug-ins list

- Photon PUN2 free edition
- Photon Voice
- Oculus Unity Integration 14.0
- VR Canvas Keyboard (developed by Peter Koch)

Key Unity packages

- Oculus Android 1.38.6
- Oculus Desktop 1.38.4
- OpenVR (Desktop) 1.0.5

Main Features

Multi-player and real-time voice chatting

Once the instructor and trainees enter the simulation, they are able to talk with each other. The instructor can see trainees' movements, but trainees cannot see the instructor's character (it is invisible for trainees).

Real-time data transfer

For synchronizing student's movement, objects' position and rotation, vital numbers and tools activation, all of them are using real-time data transfer, which makes the simulation more realistic and helps both students and instructors receive the feedback immediately.

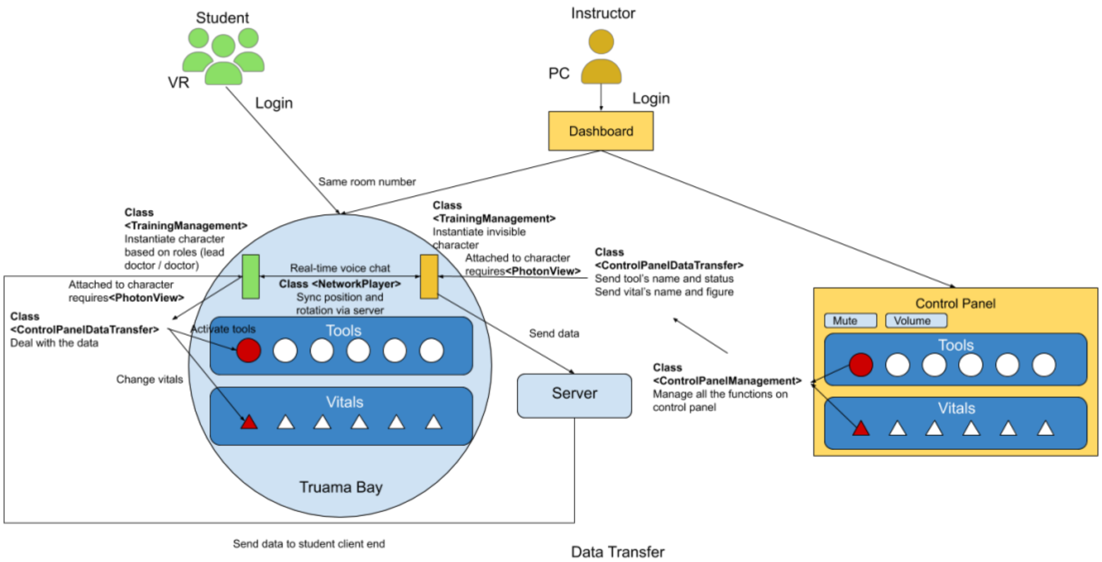
Instructor control panel

The instructor control panel is designed based on current simulation system. In the prototype, the instructor can change the vitals and active tools remotely. In a fully functional version, it will have a human body (more precise for the instructor to change mannequin's parameters), tool library (more tools can be selected and activated), recording and downloading simulation video, operation history, and many other functions that make the training more realistic and professional.

VR Interaction

In the VR world, students are able to touch and grab some specific tools and items (e.g. stethoscope, X-ray), with these items, students can get more information about the patient, which will lead them to do the right reactions.

Mock-up



Application Structure

Future Development and Vision

The future development of VCS could be built out to include the following features. Recommended practice would include regular user-testing.

Server Limitation

Currently, Photon server free edition only allows up to 20 people online at the same time. In the future, it is necessary to have a big and stable server in order to offer better service for students and instructors.

Multiplayer

Multiple trainees can access the same virtual environment simultaneously with a unique access code. In the environment they are able to view the other user's avatar. Users can collaborate and communicate with one another and do not need to be in the same location to enable multiplayer mode. Students could see each other's Avatars and names in the virtual environment (The function has been implemented but needs testing).

Realistic Avatars

Students can have a realistic avatar when they are doing the training, which can bring them a sense of immersive and help students and instructors to distinguish each other's identity and roles.

Interactable Items

In the future, more and more interactive tools will be added to the application, which can help students to practice how to use these tools.

Video Debrief

After the training session has ended, the instructor can download the recorded simulation to playback to the students for a debrief.

Programmed Body diagram in the control panel

The body diagram in the control panel could be fully functional inclusive with triggering actions when specific areas of the body are clicked.

Virtual recap

Instead of seeing a debrief and review of the training session by way of a computer, after the headsets have been removed, students could keep the headsets on and watch a virtual replay of their session while hearing the instructors' feedback.

Pre-set the reaction comments of the mannequin in Control Panel

Currently there the mannequin is programmed to move his mouth when the instructor presses and holds the mouth animation button. In the future, the mannequin could have pre-set phrases and expressions programmed into the control panel that could be played with the click of a button.

Timer

A timer in the instructor interface & virtual environment could allow for timed sessions and training sessions under time-pressure.

4 separate cameras of the video

The instructor view could have multiple angles for optimal viewing, including a first-person view from the lead student perspective

Marking the time in the recording

When the instructor is watching the simulation, he/she can mark the exact time where they'd like to give feedback with a note. This when the video debrief is played back, their feedback can be demonstrated at the time of the action.

Training history (for instructor)

The instructor can view and download a log of all the changes and actions they made while the training was in session.

Session History Log
The instructor could have access to an entire log of past sessions, dates, times and participating students

Simulations recorded and saved in history
Teachers and students can access and re-watch past recorded simulations for further learning.

Add, edit and customize scenarios
The interface could be customizable to allow for several pre-programmed scenarios and a library of tools and equipment that could be implemented into each scenario.

Virtual real-time instructor
Instead of just hearing the instructor through the headset, students could see a virtual instructor in the virtual world who provides instructions as if they were in the room.

Booking systems for instructors and students
Inclusive in the software could be a programmed booking system and calendar to allow for easy scheduling of training sessions that is synced with routine email calendars for optimal organization.

Accessibility
Considering the target user of the product, moving the instructor part to a web-based system would be more accessible, which can simplify the steps from booking to the training.

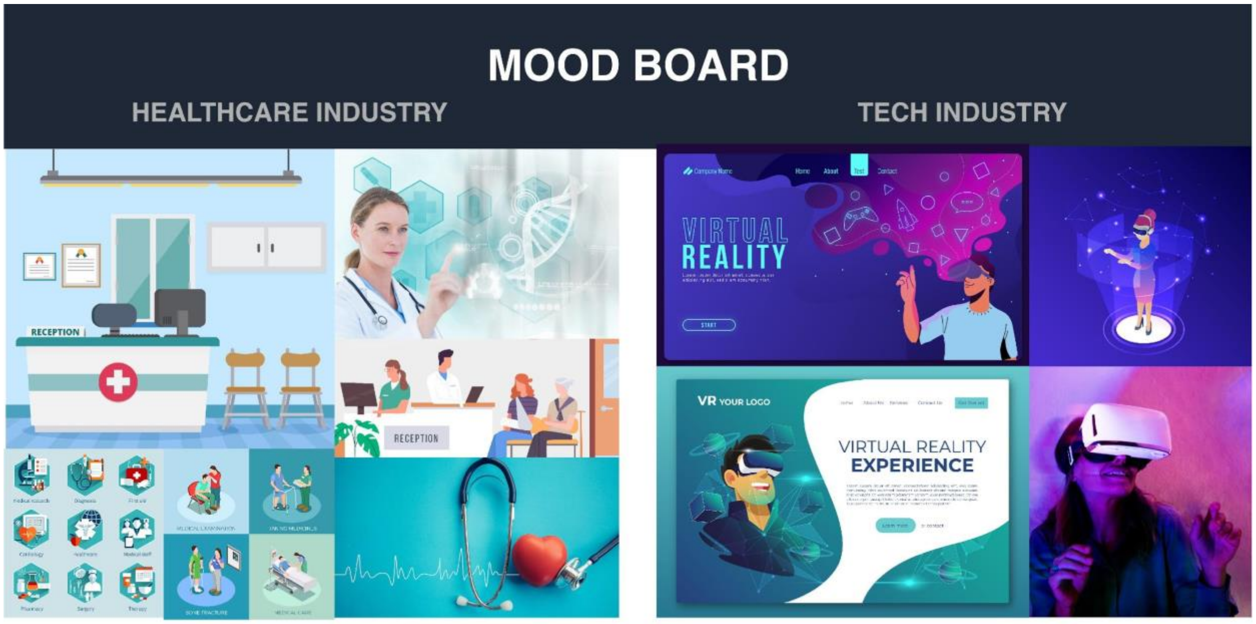
Mobile Friendly
The instructor dashboard could be programmed to accommodate Android and Apple smartphones. Sessions could be controlled from the instructor's mobile device in addition to a PC.

Language Subtitles and Translation
VCS can be accessed globally and, in the future, could include the use of subtitles to accommodate non-English speakers. Scenario descriptions and patient phrases could be translated.

Appendix

A1. Colour Rationale

A2. Mood Board



A3. Logo Mock Ups

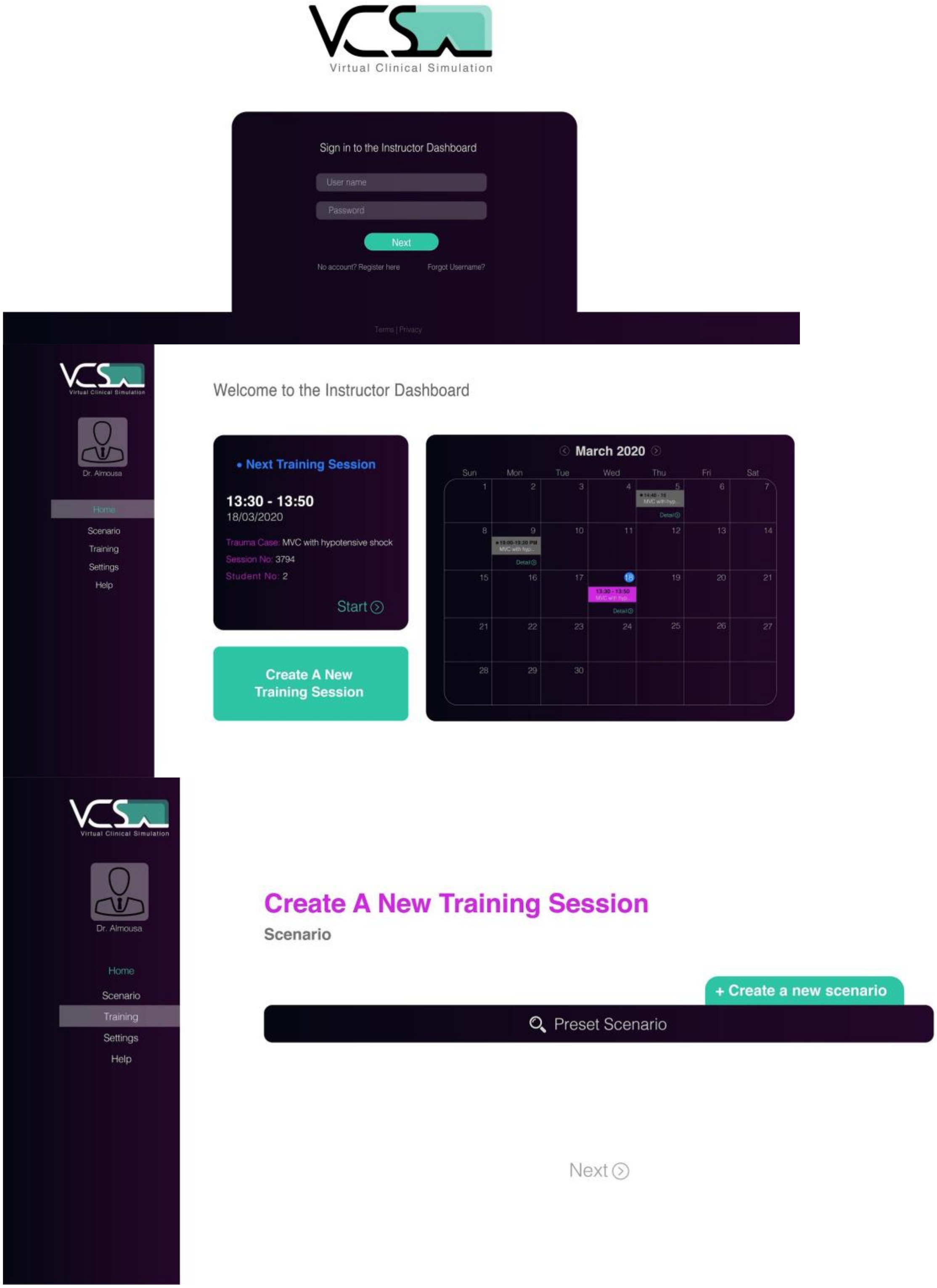
Control Panel

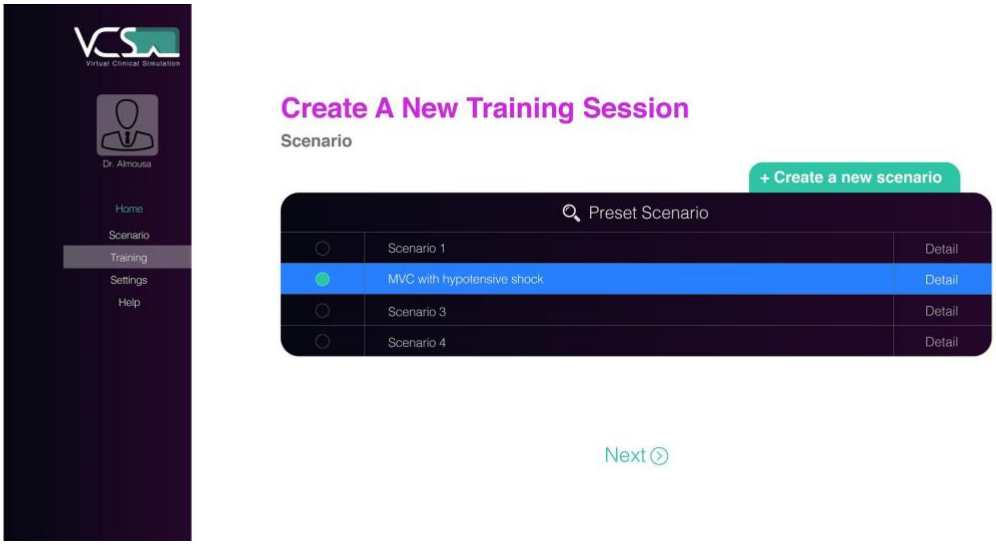
User Login

App Icon

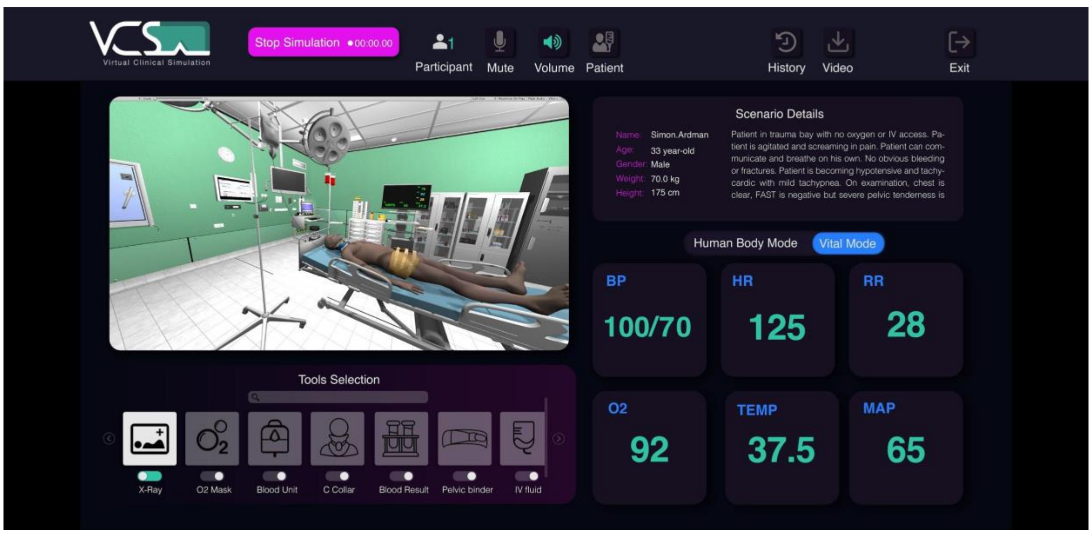
A4. UI Design

To view all UI design assets, see asset folder > design > user interface design





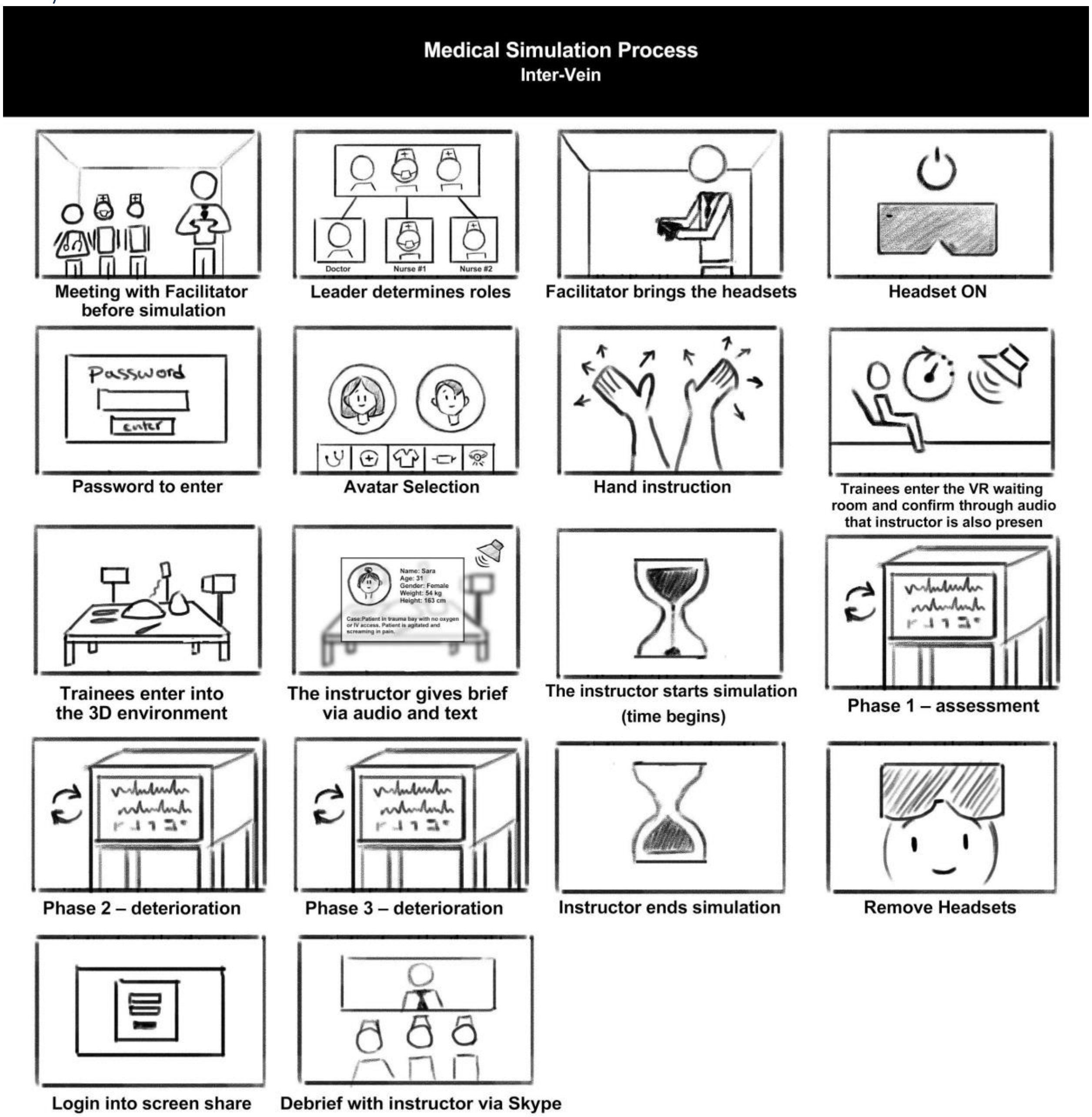
VCS
Virtual Clinical Simulation
Dr. Almousa
Home
Scenario
Training
Settings
Help
Create A New Training Session
Scenario
+ Create a new scenario
Preset Scenario
Scenario 1
Detail
MVC with hypotensive shock
Detail
Scenario 3
Detail
Scenario 4
Detail
Next



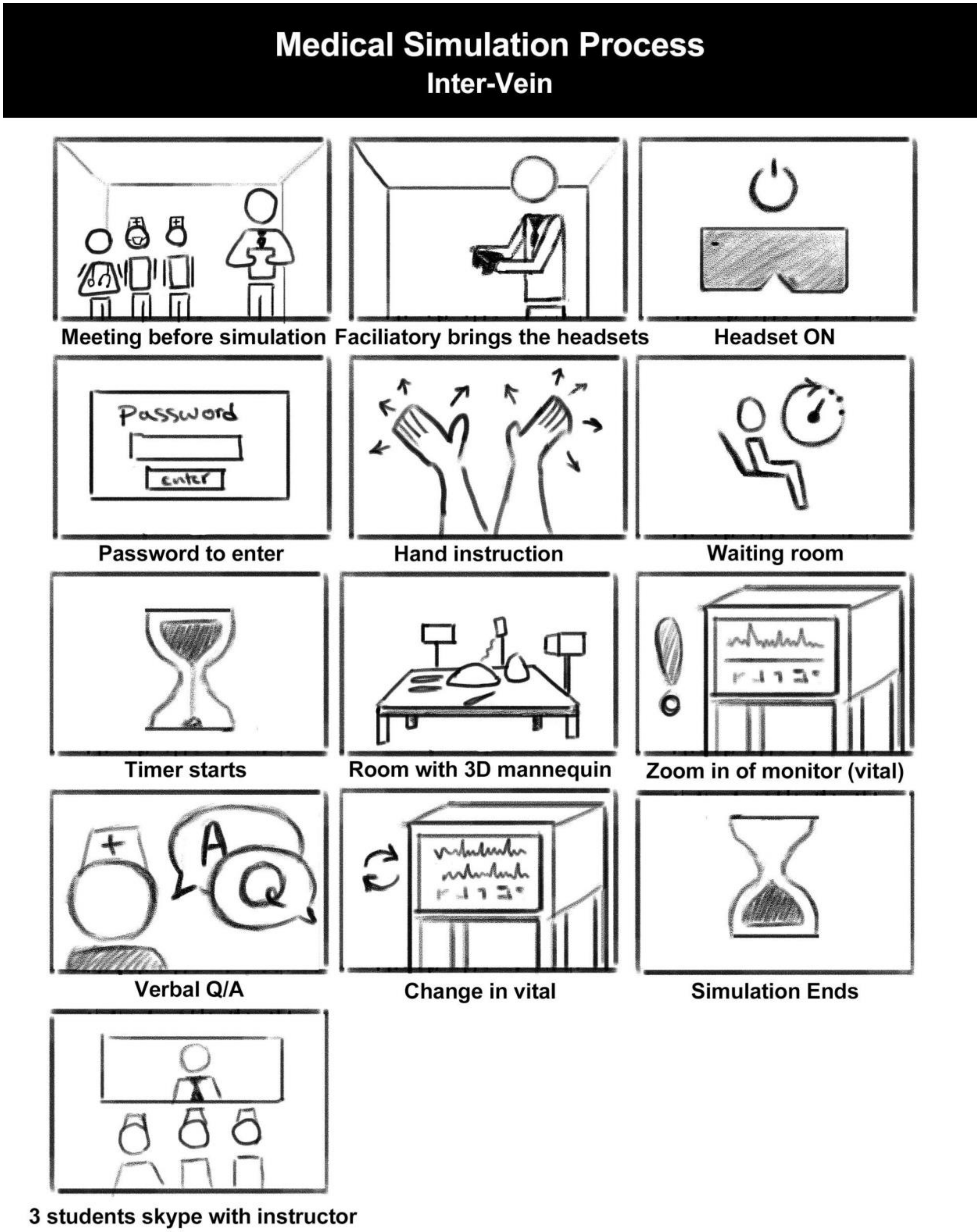
VCS
Virtual Clinical Simulation
Stop Simulation
00:00.00
Participant
Mute
Volume
Patient
History
Video
Exit
Scenario Details
Name: Simon.Ardman
Age: 33 year-old
Gender: Male
Weight: 70.0 kg
Height: 175 cm
Patient in trauma bay with no oxygen or IV access. Patient is agitated and screaming in pain. Patient can communicate and breathe on his own. No obvious bleeding or fractures. Patient is becoming hypotensive and tachycardic with mild tachypnea. On examination, chest is clear, FAST is negative but severe pelvic tenderness is
Human Body Mode
Vital Mode
BP
100/70
HR
125
RR
28
O2
92
TEMP
37.5
MAP
65
Tools Selection
X-Ray
O2 Mask
Blood Unit
C Collar
Blood Result
Pelvic binder
IV fluid

A5. Storyboards

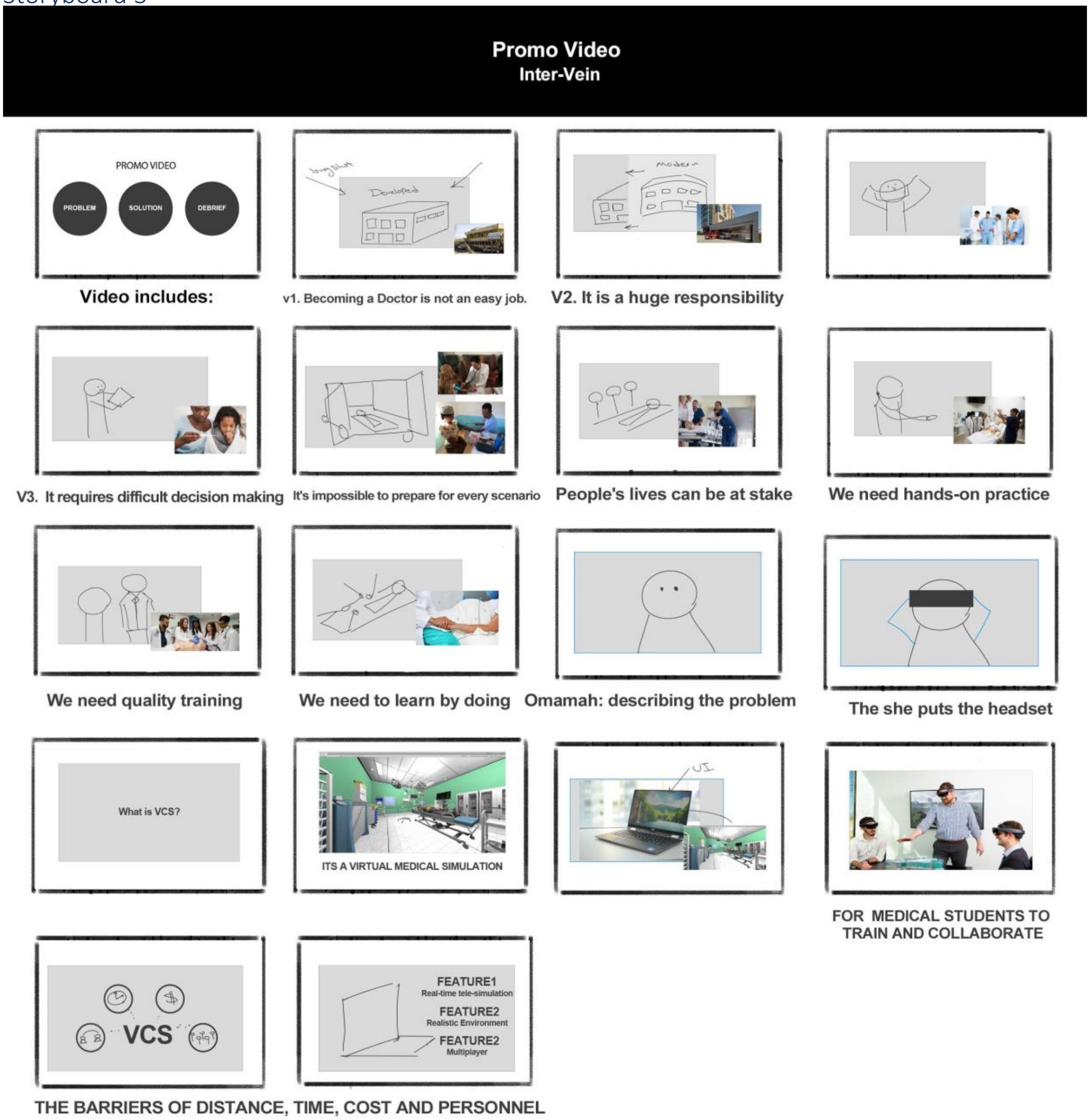
Storyboard 1



Storyboard 2



Storyboard 3



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