Maneuvr VR

by

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Abstract

The training that is required in the manufacturing industry is costly and dangerous. When a new employee is hired, a senior, more experienced employee must take time to train them. This leads to slower production and an increased cost in labor. There are also significant risks when the new employee is interacting with heavy machinery. The new employee does not likely have the knowledge of how to use the machinery and is at a higher risk of injuring themselves or others. Maneuvr VR is a VR solution that solves these problems. It's simulation can supplement job training in a way that other mediums cannot. This allows for the more skilled employees to spend more time in the production environment and reduces the risk compared to traditional training. The environment will feel familiar to the new employee and will result in a higher level of professional confidence.

1.1 Problem

In manufacturing, when it comes to the production line, getting it right the first time is essential, especially in the automotive industry. Many industries have been quick to embrace the latest in technology and software to pump up their production numbers and amp up their profits. There has been one area, however, that has been slow in adapting to these technological advancements despite its absolute importance; the training of employees. Manuals, videos, and tests are still the norm for many companies and can lead to a disengaged employee if the material is too dense. If an automotive company is creating 200 automobiles a day and just 3% of daily production has been identified to contain defects, at the average cost of $10,000 a car, that company has just delayed a profit of $60,000 in one day alone. Sending defective or dangerous cars into the market also has many more serious ramifications. “In 2004, in the U.S. alone, defects stemming from the production line accounted for 22,000 deaths, about 29.5 million injuries, and over 700 billion dollars in losses as a result of “unsafe‟ and “defective‟ products statistics have shown (Xiuli, Baozhi and Hanqing 2012).” There are several methods companies can employ, but the only thing that can solve this issue in most cases, is the training of the employee on the production line. Luckily, we’re developing a solution to this problem. Virtual Reality has made leaps and bounds in the last few years and finally the time is ripe for many more industries to take advantage of this advanced technology. With Maneuvr VR Software, we will be able to place your employee in a virtual workstation that is a 1:1 replica of their work area and will contain tasks that mimic their on-the-job responsibilities. The Maneuvr VR software will allow you to assemble parts, operate machinery and take quizzes in a safe, easy to replicate and easy to use environment that is interactive and

fully customizable. Through our robust requirements gathering process we can make the simulation follow the same processes and functions that would take place during a normal day's work. Also, while the user is operating the software, Maneuvr VR will be able to collect data and engagement in real-time allowing us to gage the effectiveness and immersion of the training. With the Maneuvr VR software, employees will take less time to train, create fewer defects, create less downtime, and boost production output as well as quality across the board.

1.2 Solution

Maneuvr VR is a virtual reality training software that aims to improve training in manufacturing. Each instance of Maneuvr VR will consist of a set of tailored 1:1 modules of the trainees' workspace that will allow them to interact and learn in a virtual environment. To get an exact environment, we will travel to the sight that we are modeling and will take detailed scans of the environment and the tools that we will use while creating the modules. This will ensure that there is little difference between the real world and virtual world as possible. On top of real world look, we will have vibrations that coincide with the interactions of objects that will allow the user to feel when they are interacting with an object. With training modules that will allow the user to safely interact with the environment that they will be working in, the user will more fully grasp the knowledge of how to perform the task at hand and will have less of a chance to get injured during the job. With physical training, there is a higher variability between training sessions and this leaves room for error. With Maneuvr VR every training module will be the same set of instructions, making sure that the user gets all the required information that

they need. Furthermore, the system will monitor the movements of the user and the user will also be required to take quizzes to pass the modules ensuring that the information is retained.

1.3 Project Goals

- Interactable Modules ranging in complexity.
- Workspace that is as close to 1:1 to a real workspace as possible.
- Main menu where the user can modify settings and choose training modules.
- Provide user data that would allow the company to evaluate the users' performance.
- Provide modifiable quiz modules that test the user's knowledge on the subjects.
- Guided process completion that will simulate what it is like to be in the workspace.
- Visual, Auditory and Haptic feedback when interacting with the modules.
- Simulated environment for user immersion.
- Protection of business processes and product intellectual properties.

1.4 Overview

The remainder of this paper is outlines how we completed this project. The report includes the following sections: project concept, design objectives, methodology, problems encountered, use case, user diagram, a Gantt chart of the development timeline, budget and a conclusion of the project.

2.1 Project Concepts

- Virtual Reality can replicate real workplace tasks and conditions.
- Employees will be more engaged in a VR simulation than through traditional training methods.
- Adequate knowledge transfer can take place through accurate simulation.
- Rich data can be collected and can provide insights into training effectiveness through tracking users movements, actions and answers in the simulation.

2.2 Design Objectives

Our main goal to design a VR training application that is a 1:1 replica of a workstation for. By having interactive modules, it enables trainees to start with easier tasks and work their way up to harder ones. The application will also have different settings that the users can modify to their comfort. Not only the application provides a safe environment for trainees, it also provides help for the trainees during the training process. Instead of having a manager help every single trainee, the built-in guide will be embedded to the application. With the help of virtual reality, we can create any module a company would like. Because of that, our VR simulation should be engaging and realistic, providing cues through visual, auditory and haptic feedback that react to users' actions in real time and guide them through the process in which they are being trained. Finally, the application will also have interactive quizzes and data for the company to access the trainee's progress within the training modules. The company will be able to modify their materials depending on a trainee's experience. At the end of the training, the

application will generate a report based on a trainee's performance that will available for the company to evaluate.

2.3 Methodology

1. Gather insight into processes employees will engage in during working hours.
    a. Use existing training material
    b. Use trainers' knowledge of processes
    c. Document steps per task
    d. Document challenges employee may face.
2. Track sequence of events and tasks and create a storyboard.
    a. Using storyboard software to create in depth storyline.
3. Scan and import real workstation tools and environment.
    a. Take 360-degree photos of items in workstation.
    b. Use AutoDesk ReCap and Remake to virtualize assets.
4. Build simulation based on existing training materials and processes, in proper sequence.
    a. Place assets in Unity3D and use scripts force employee to follow sequence.
5. Collect data on employee performance.
    a. Create background scripts to pick up on head movement, wrong answers, and incorrect sequencing.
6. Use data to generate reports and gauge success of VR training.
    a. Use Excel to create graphs and bar charts to examine employees' performance.

2.4 User Profile

Table 1: User Profile, demonstrate the user profile for the Maneuvr VR application. This user profile consists of the application's potential users, the software and interface used, and experiences the users will need and obtain after using the Maneuvr VR.

USER PROFILE
PROJECT: Maneuvr VR
POTENTIAL USERS: • Managers (trained employees) • Trainees (new hires, existing employees)
SOFTWARE, INTERFACE, AND RELATED EXPERIENCE: All Maneuvr VR users will enter virtual reality training site application. Therefore, users will be required to wear a VR headset and controller. Even though the training site is virtual, users are also required to be set up in an open area so that there is enough room to move around.
EXPERIENCE WITH SIMILAR APPLICATIONS: Maneuvr VR users may have virtual reality experience from using any VR related activities.
TASK EXPERIENCE: Before a trainee open the VR application, a manager will create a user, enter quiz questions and update the system's setting depending on the user's experience. After the manager complete the initial setup, the trainee will open the application and put on a VR headset and controller. Then, the trainee will be able to log in with the provided credentials and begins to interact with the

environment, take quizzes and view training modules. In the end, both the manager and trainee will be able to view training data results.
FREQUENCY OF USE: Maneuvr VR will be used whenever there is a need to train users. This occurrence can happen daily, weekly, monthly, or yearly depending on how much training is required.
KEY PROJECT DESIGN REQUIREMENTS THAT THE PROFILE SUGGESTS: • Simple, responsive user interface, allowing users to easily find and view training modules • Interactive design, ensuring that users will complete the training • User accounts, ability to assign users different training depending on their positions • VR provides a safe environment to train in

Table 1: User Profile

2.5 Use Case Diagram

Figure 1: Use Case Diagram, illustrates the user case for Maneuvr VR application. The diagram shows all the actions available for the end users.

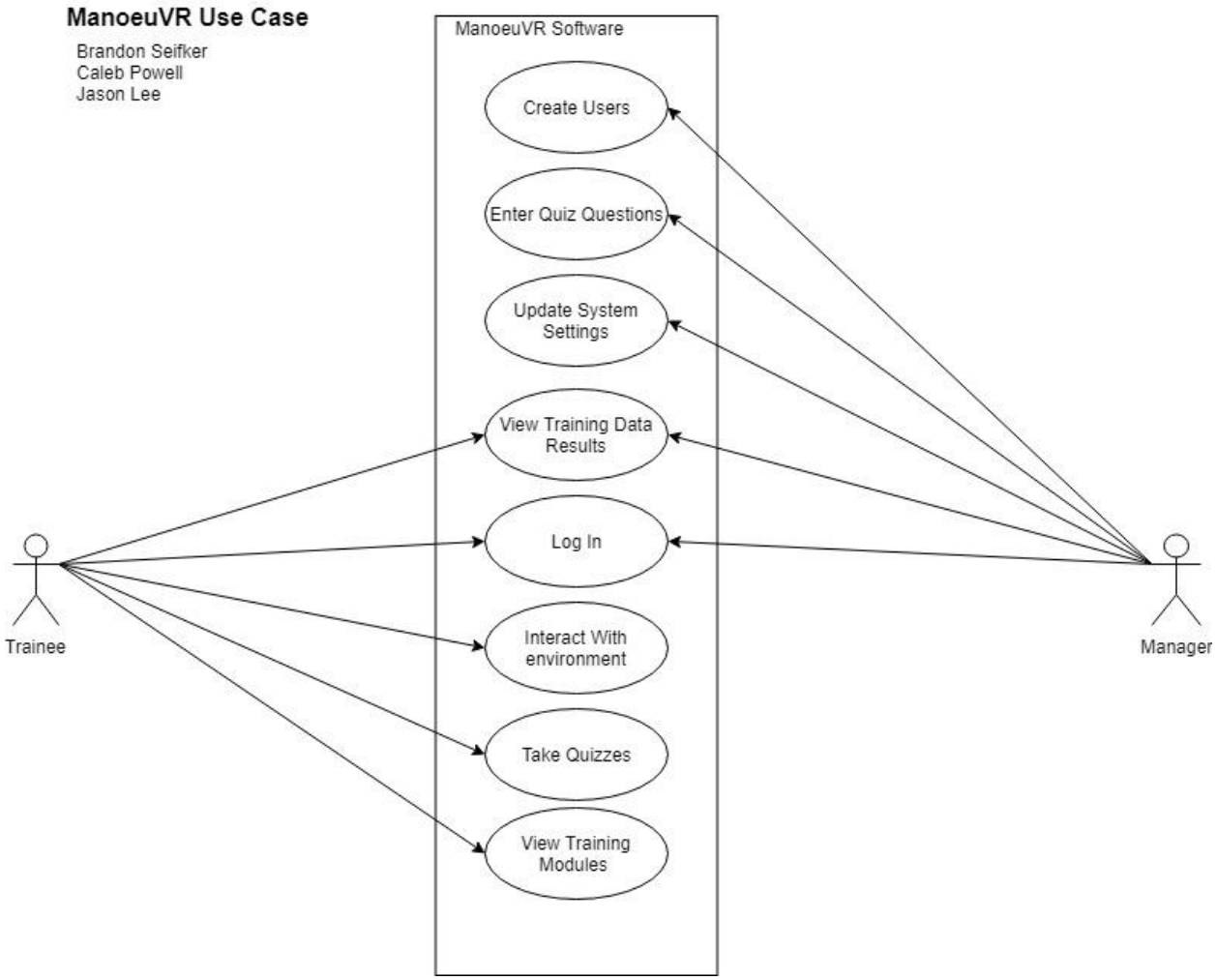


Figure 1: Use Case Diagram

2.6 Project Schedule

Assignments

Table 2: This table shows the due dates of all assignment pertaining to the Senior Design Project Management course.

Senior Design Project Management Assignments	
DUE DATE:	DESCRIPTION:
04/09/2019	**1. Senior Design Project Management**
09/03/2018	1.0 Team Members & Project Name DUE
09/24/2018	1.1 Team Contract DUE
10/15/2018	1.2 Project Abstract for Tech Expo DUE
10/15/2018	1.3 Team Contract Resubmission DUE
10/22/2018	1.4 Three Minutes Elevator Speech
10/22/2018	1.5 User Profile DUE
10/22/2018	1.6 Use Case Diagram DUE
11/05/2018	1.7 Draft Report DUE
12/03/2018	1.8 Final Fall Semester Report DUE
12/03/2018	1.9 Project Formal Presentation
02/11/2019	1.10 Testing Plan Report DUE
02/18/2019	1.11 Revised Abstract DUE
03/04/2019	1.12 Tech Expo Poster Draft DUE
03/11/2019	1.13 Final Formal Presentation
03/18/2019	1.14 Tech Expo Poster Final DUE
04/15/2019	1.15 Final Report DUE
04/29/2019	1.16 Final Library Copy DUE

Table 2: Assignment Due Dates

Work Breakdown Structure

Table 3: Work Breakdown Structure (WBS) is a breakdown of the deliverables into manageable sections to help the team work better. The table below describes all key project deliverables that the team needs to complete to build the Maneuvr VR application.

Level	WBS Code	Name	Definition
1	1	Create Training Simulation	All work to create a VR training system
2	1.1	Customer Outreach	Work to ensure and provide quality to the client
3	1.1.1	Pool Potential Candidates	Brainstorm potential clients and their areas that would benefit from VR training
3	1.1.2	Contact Potential Candidates	Reach out to potential clients and see if they're interested in sampling our program
3	1.1.3	Initial Requirements Gathering	Meet with clients and get all relevant details about their current training system and how to adapt it to a VR simulation
3	1.1.4	Beta / Demonstration Feedback Gathering	Provide the clients with a prototype and receiving feedback and list of improvements
3	1.1.5	Alpha Launch	Provide client with finished VR training simulation
3	1.1.6	Follow Up Feedback Gathering	Follow up and help clients interpret training data and check for possible improvements
2	1.2	Menus / Lobby	Landing point on launch of simulation, allow a user to adjust settings to fit their comfort and familiarize them with the mechanics of the simulation
3	1.2.1	Branding Splash Screen	Provide a brief company splash screen with logo and branding for brand identity
3	1.2.2	Initial Menu	Take in employee information
3	1.2.3	Settings	Allow for adjustments in visuals, brightness and audio to ensure user comfort
3	1.2.4	Training Course Selection	Allow user to choose which simulation to start
3	1.2.5	General Use Tutorial	Familiarize user with the controls and concepts that will drive the simulation

2	1.3	Task Simulation	The actual VR simulation as laid out by the client and implemented by our team
3	1.3.1	Storyboard	Draw out how the simulation will flow, which tasks they'll be asked to do and in what order
3	1.3.2	Base Functionality	Create modules for UI interaction, object physics, movement and object manipulation
3	1.3.3	Asset Virtualization	Scan objects in actual workplace, build and fine tune them for most accurate representation in VR simulation
3	1.3.4	Scene Building	Build the workplace in the simulation using photos, UI, textures and objects
3	1.3.5	Functioning Workflow	Finalize the order of events in the simulation and update documentation to reflect the choices made in creating/setting up the simulation
3	1.3.6	Course Specific Tutorial	Create comprehensive tutorials to familiarize the user with the tasks they'll be expected to execute in the simulation
2	1.4	Quizzes	Quiz the employee's knowledge of actual training concepts and processes both before and after simulation
3	1.4.1	Answer/Question Bank	Collect questions from client relevant to the training and their corresponding answers to quiz the employee on before and after training
3	1.4.2	Read-in Functionality JSON/XML	Create an external document to be read in to the simulation containing the questions, answers and action prompts relevant to the training
3	1.4.3	Format to UI	Adapt questions to fit cleanly into the UI of the training simulation
3	1.4.4	Answer Validation	Check the user's responses to questions and give them a correct or incorrect based on the answer bank
3	1.4.5	Tally Results	Calculate the users grade from both the quizzes and their performance in the simulation
3	1.4.6	Display Results	Show the user their score and give a breakdown on strengths and weaknesses
2	1.5	Data Collection	Collect user prior knowledge, engagement and knowledge post training and write them into an external document

3	1.5.1	Pre-Training User Survey	Collect user's answers on relevant concepts, processes and questions to create a baseline for comparison in effectiveness of training
3	1.5.2	False/True Input Collection	Collect user's input through button presses and whether it corresponds to actual tasks or processes in simulation (true) or failures to follow simulations directive and prompts (false)
3	1.5.3	Quiz Score Collection	Collect user's end score and attach it to their name in an external tracking document
3	1.5.4	Gyroscope Collection	Collect the user's head movements to check if they're engaged and following the training or distracted
3	1.5.5	Aggregate Data	Sort data in external document on relevant variables, build graphs and summaries
3	1.5.6	Trend Spotting	Identify trends in user input, interaction, prior knowledge and effectiveness of training

Table 3: Work Breakdown Structure Table

Figure 2: WBS, a visual aid that help to better illustrates the three levels of the WBS.

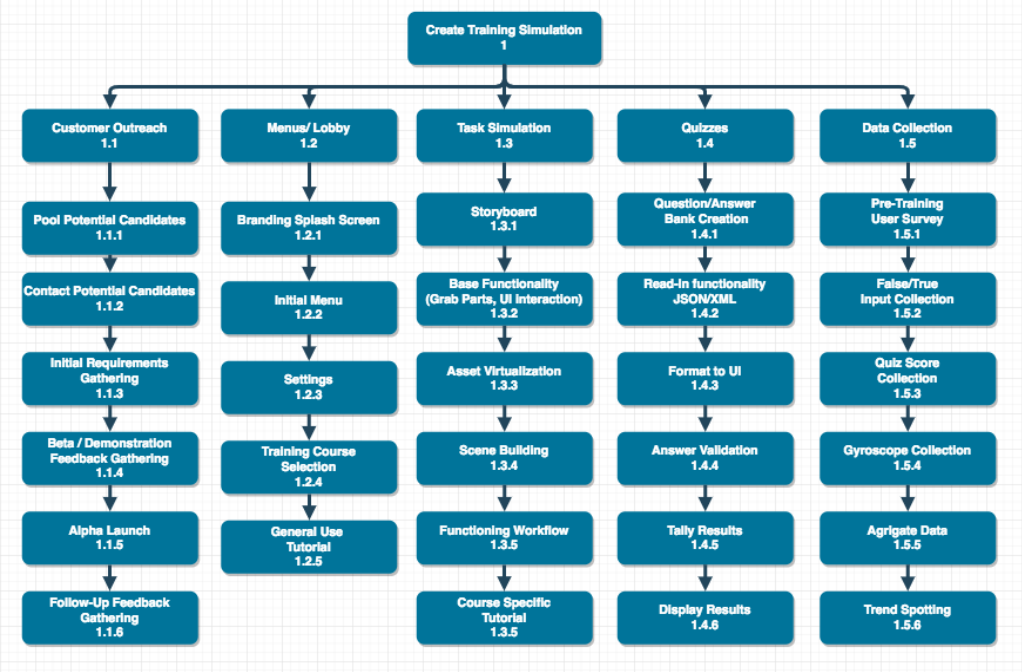
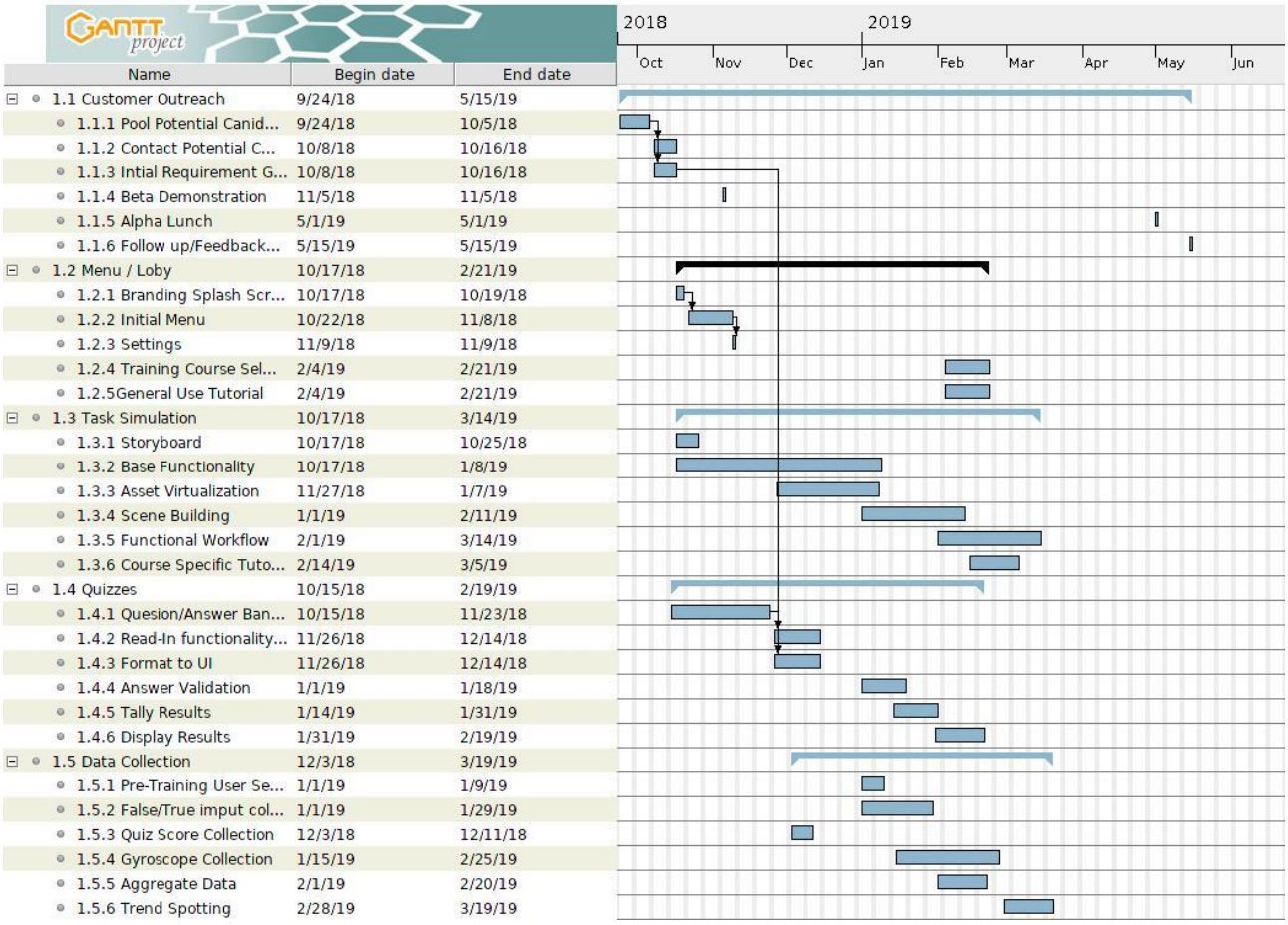


Figure 2: Work Breakdown Structure Visual

Gantt Chart

Figure 3: Gantt Chart, is another visual aid to showcases all the deliverables from the WBS and the timeline of the project throughout the entire school year.



Name	Begin date	End date
1.1 Customer Outreach	9/24/18	5/15/19
1.1.1 Pool Potential Canid...	9/24/18	10/5/18
1.1.2 Contact Potential C...	10/8/18	10/16/18
1.1.3 Intial Requirement G...	10/8/18	10/16/18
1.1.4 Beta Demonstration	11/5/18	11/5/18
1.1.5 Alpha Lunch	5/1/19	5/1/19
1.1.6 Follow up/Feedback...	5/15/19	5/15/19
1.2 Menu / Loby	10/17/18	2/21/19
1.2.1 Branding Splash Scr...	10/17/18	10/19/18
1.2.2 Initial Menu	10/22/18	11/8/18
1.2.3 Settings	11/9/18	11/9/18
1.2.4 Training Course Sel...	2/4/19	2/21/19
1.2.5General Use Tutorial	2/4/19	2/21/19
1.3 Task Simulation	10/17/18	3/14/19
1.3.1 Storyboard	10/17/18	10/25/18
1.3.2 Base Functionality	10/17/18	1/8/19
1.3.3 Asset Virtualization	11/27/18	1/7/19
1.3.4 Scene Building	1/1/19	2/11/19
1.3.5 Functional Workflow	2/1/19	3/14/19
1.3.6 Course Specific Tuto...	2/14/19	3/5/19
1.4 Quizzes	10/15/18	2/19/19
1.4.1 Quesion/Answer Ban...	10/15/18	11/23/18
1.4.2 Read-In functionality...	11/26/18	12/14/18
1.4.3 Format to UI	11/26/18	12/14/18
1.4.4 Answer Validation	1/1/19	1/18/19
1.4.5 Tally Results	1/14/19	1/31/19
1.4.6 Display Results	1/31/19	2/19/19
1.5 Data Collection	12/3/18	3/19/19
1.5.1 Pre-Training User Se...	1/1/19	1/9/19
1.5.2 False/True imput col...	1/1/19	1/29/19
1.5.3 Quiz Score Collection	12/3/18	12/11/18
1.5.4 Gyroscope Collection	1/15/19	2/25/19
1.5.5 Aggregate Data	2/1/19	2/20/19
1.5.6 Trend Spotting	2/28/19	3/19/19

Figure 3: Gantt Chart

2.7 Budget

Table 4: Project Budget shows the budget for the entire project. This is an estimate of what it would cost if it was in the real world. But since this is our Senior Design project, it does not cost anything as our equipment and software are owned or borrowed.

Item	**Estimated Price**
Unity Software	$1500 (12 months)
Oculus Rift	$349 (1)
VR Ready PC & Monitor	$2000 (1)
Estimated total for 1 machine for 1 year	**$3849**

Table 4: Project Budget

As shown in the table above, it would cost only $3849 for total equipment cost to develop for one VR machine. Company can purchase as many machines as they needed.

2.8 Problems Encountered

- The main problem that we have faced thus far is that we were not able to get our hands on a VR device. We were unaware that the university had a room that had one that we could use any time and we were slow on getting a response on if we could check one out. But we managed to loan out a VR headset at least once a week to test out the application.
- The second problem that we have faced since the start of the project is a learning curve. While there is some knowledge that can be applied from our schooling on the code side, there is a lot to learn when it comes to using Unity and the graphic design portion of the project. We have started to overcome this by relying on pre-made 3D graphics and watching videos to learn the basics as we design the rest of the software.

3.1 Test Plan Overview

This section will explain the testing methodology for the Maneuvr VR application. The following individuals should use this test plan:

- Developers
- Project Managers
- Team Members
- Security Analysts
- Testers

3.2 Scope of Testing

The scope of testing is to test the operation of the Maneuvr VR application on the specialized hardware (Oculus Rift). Testing will be organized based on the requirements of the application.

3.3 Testing Objectives

The objective of testing is to verify that the application runs properly with the Oculus Rift and includes enough objects that are required. This test is to ensure the overall objects are colliding and functioning correctly. Confirm that the application would not cause physical consequences such as headaches, seizures, motion sickness, eye strain, etc.

3.4 Entry and Exit Criteria

- Entry Criteria:
    - Environment and hardware setup
    - Application successfully running

    - Testing module is setup
- Exit Criteria:
    - All tests are run
    - Bugs are documented and fixed
    - Environment tear down and hardware return

3.5 Logging Test and Reporting

If there is a discovery of a bug during the operation of the application, the individual testing the application will document the bug. The report will then be discussed with the developers and project managers to determine the next steps. Once decisions are made, the developers will make changes based on what was discussed and severity.

3.6 System Testing

Maneuvr VR will be tested as a complete application with the Oculus Rift headset together with all the testing modules as one unit. Testing with as a unit will help to identify bugs in a real time environment and allow testers to simulate what the end users will experience in the end-product.

3.7 Testing Procedures

The following are steps needed for appropriate testing:

- Create test scenarios and test cases
- Prepare documents of steps to run the test and expected results
- Identify and document bugs in report
- Rank bugs based on severity

- Resolve bugs

The following are tests that will be performed:

- Stability Test – This test will focus on whether the application is stably running on Windows.
- Launch Test – This test will focus on whether the application being able to start and stop properly.
- User Interface Test – This test will focus on how the user manage to navigate the user interface and how it appeals to the user.
- Functionality Test – This test will focus on the features and modules that are implemented in the application and whether the application is working as expected.
- Accessibility Test – This test will focus on whether if there are any physical consequences such as headaches, seizures, motion sickness, eye strain, etc. while using the application.

3.8 Pass/Fail Conditions

Maneuvr VR application will be using pass/fail assessment. It is expected that the application must pass in every category and full run through without any errors before release. All items that failed during the testing phase must be resolved by the project managers and developers to be considered as a "pass."

3.9 Schedule of Team Member Testing

Table 5: Schedule of the member testing

Team Member	Timeline	Frequency
Project Manager	12/03/2018 – 04/09/2019	Weekly
Developers	12/03/2018 – 04/09/2019	Weekly

Table 5: Schedule of Team Member Testing

3.10 Risks

The following will impact the test schedule:

- Rift Oculus availability
- Tester's schedule availability
- Delay in bug fixes

3.11 Test Results

Table 6: The test results table shows the results of the stability test, launch test, user interface test, functionality test an accessibility test.

Tester	Date	Test Category	Expected Outcome	Actual Outcome
Developer	02/08/2019	Stability Test	Maneuvr VR operates smoothly, lag-free,	Maneuvr VR operates smoothly, lag-free
Developer	02/08/2019	Launch Test	Maneuvr VR successfully turned on & off	Maneuvr VR successfully turned on & off
Developer	02/08/2019	User Interface Test	Navigate all the modules & user interface	Was able to navigate all the modules & user interface
Developer	02/08/2019	Functionality Test	All implemented features and modules are functioning	Features working as intended, objects move and collide freely

Developer	02/08/2019	Accessibility Test	No physical harm/consequences	Was able to use the application without any physical troubles

Table 6: Test Results

3.12 Lessons Learned and Conclusion of Testing

Developing for Unity requires an awareness of how users interact with the space around them as well as objects within that space in a virtual environment. Scale, color, lighting, audio, and haptic feedback all play powerful roles in bringing the virtual environment to life. In the initial setup of Maneuvr VR many of the main functions came together easily as well as the implementation of the virtual space. The functionality alone, however, wasn't enough to submerse the player into the task at hand. To fix this issue we tested different lighting scenarios, skyboxes and equipment setups until we found the ones with the most organic and natural look in the context of the simulation. Future iterations of testing will also focus on the goal of creating an immersive environment with an emphasis on having clear objectives and reinforcing them through all avenues of feedback to the player.

4.1 Technical Elements: Network

Maneuvr VR is run locally on Virtual Reality capable hardware (such as an NVIDIA 1060 X and the Oculus Rift). Maneuvr VR requires a simple internet connection, by wire or Wi-Fi to send a summation report of the users' activity via email and SMTP Protocol.

4.2 Technical Elements: Application

Maneuvr VR operates within one compiled application which makes up for all the methods, classes, UI as well as modeling and physics components. Unity was used in the creation of Maneuvr VR and our program has the ability to Run entirely independent of it. SMTP protocol is used upon completion of application and can send to any valid email address.

4.3 Technical Elements: Security

Like any other Internet of Things devices, VR platforms lack some of the essential security mechanisms. Up to this point, there aren't any security risks that are threatening IT professionals about VR security issues. In the meantime, Maneuvr VR will stay alerted and run the latest software to ensure that there won't be any security issues due to outdated programs. Besides being connected to the network, the application will only have access to send results to emails or potentially databases.

5.1 Recommendations for Improvement

Maneuvr VR would benefit from a custom physics engine as well as a revamp to shaders and graphic content. Working with Unity's default physics engine left a lot to be desired, but it did help us get our project up and running quickly. Other parties' feedback was very positive on the immersive quality of the simulation. A better in-application demonstration would have also helped. With more time we could span out into different simulations like safety and other workplace training topics. For the time being we don't have a plan for ongoing updates.

5.2 Visuals

Figure 4: This figure shown below is the IT Tech Expo Poster of the project. The poster is physically printed and is showcased during the IT Tech Expo.

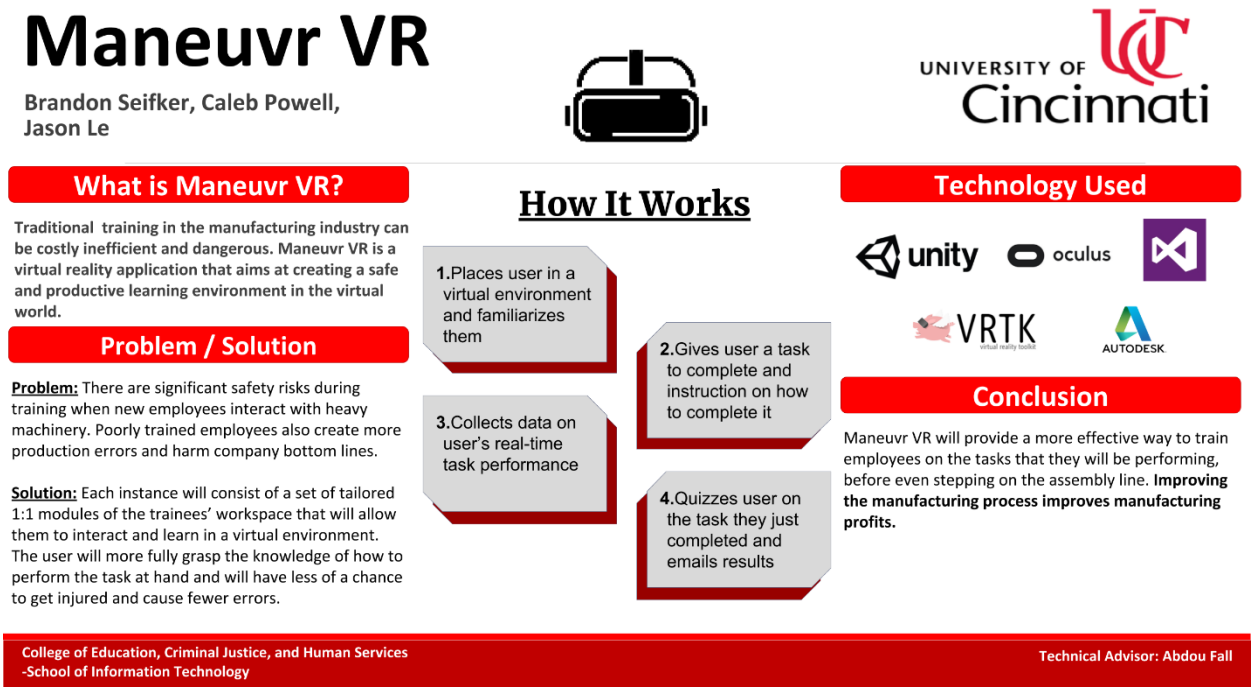


Figure 4: Tech Expo Poster

Figure 5: This figure shown below is the UI that catches the employees name for the summation report.

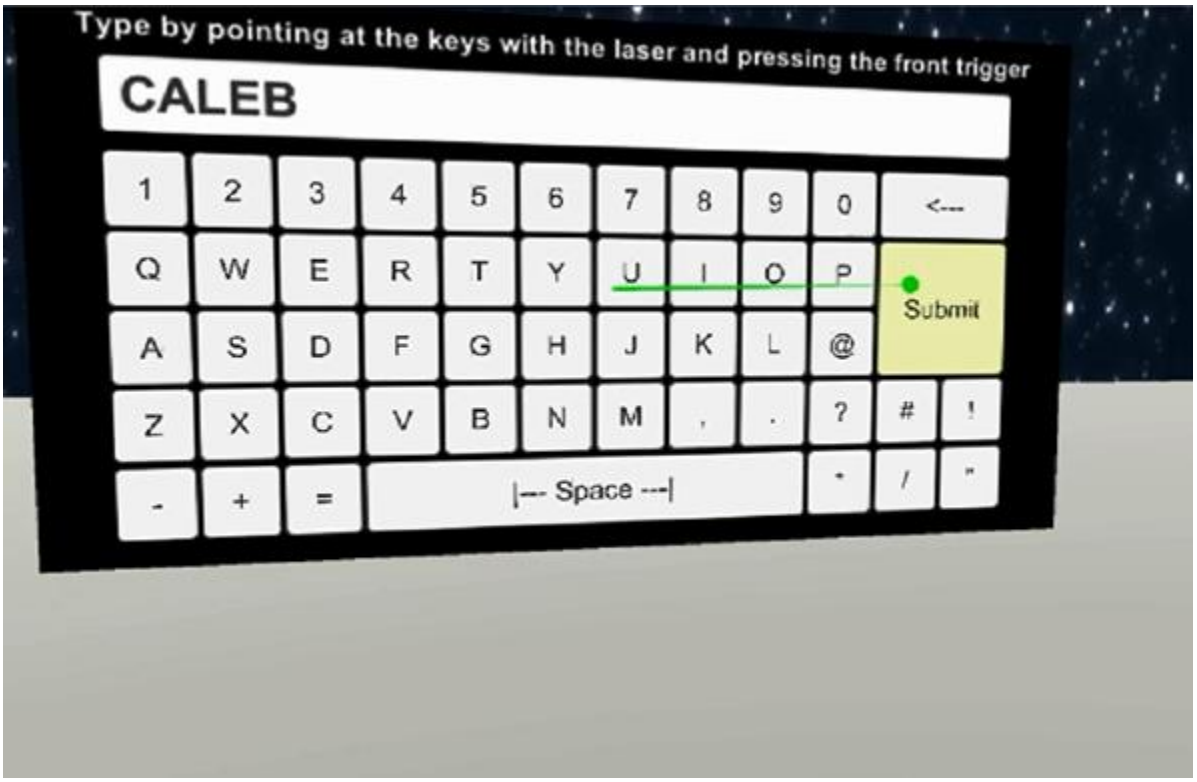


Figure 5: Screenshot 1

Figure 6: This figure shown below is the bolt and screwdriver in their virtual environment. They are both grabbable and can be rotated and manipulated. The drill has audio as well as haptic feedback.

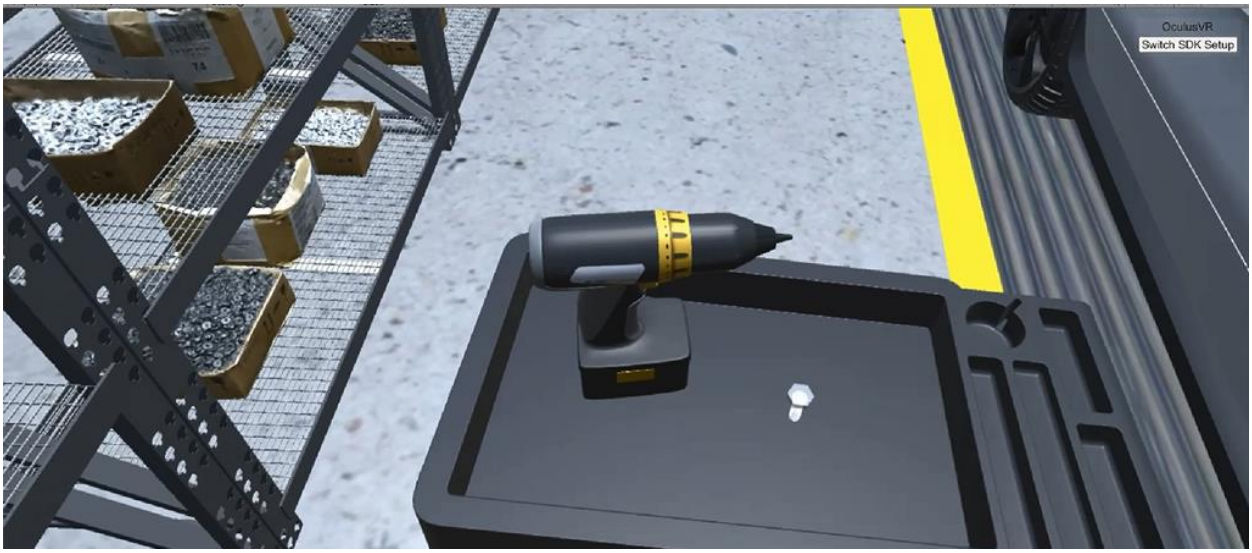


Figure 6: Screenshot 2

Figure 7: This figure shown below is the employee attaching the bolt to the drill.

Figure 7: Screenshot 3

Figure 8: This figure shown below is the screwdriver attaching the bolt to the tire.

Figure 8: Screenshot 4

Figure 9: This figure shown below is a question from the test the employee is graded on after completing the simulation.

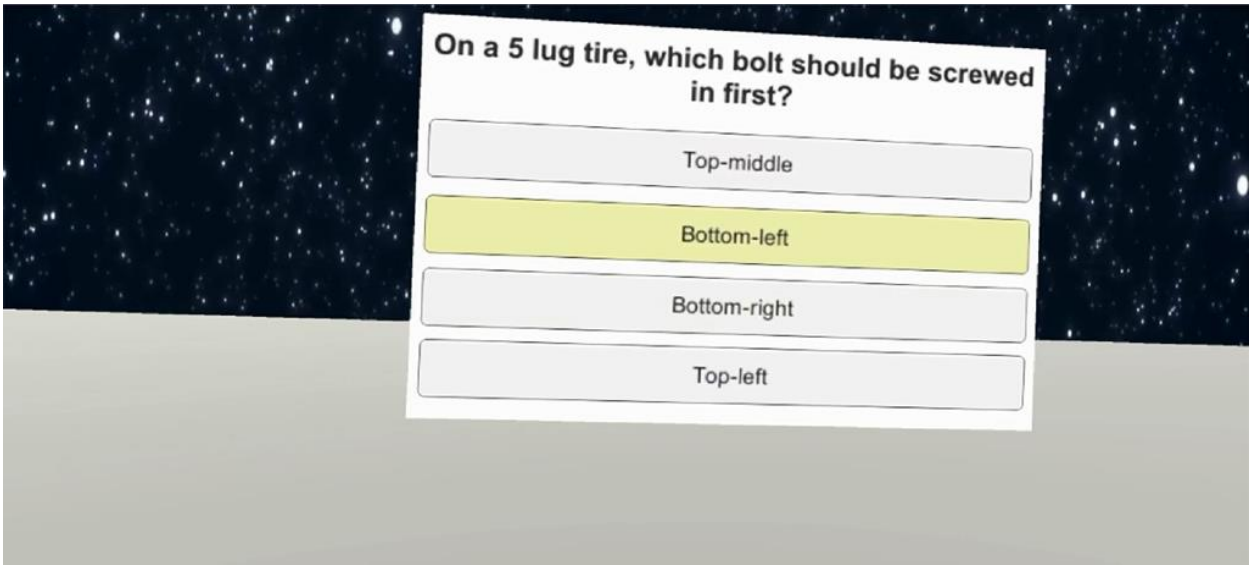


Figure 9: Screenshot: 5

6.1 Conclusion

This semester we learned a lot about curating User Experience within a virtual reality environment. This required us to improve our skills in Object-oriented Programming, C#, Graphic Design, User Interface Design, the Unity engine, Oculus Rift technologies as well as learning in leadership, accountability and team work. We completed our goal of creating a working, on the job training simulation by leveraging these skills and working to each other's strengths. Last semester we learned about the planning process that is required for an application of this size such as Gantt Charts, Work Breakdown Structures, User profiles and more. Doing these portions of the project correctly and on time propelled us into spring when we were able to get many of the finer tuned technical elements complete. At Expo we were proud of what we created and the reception we got. Overall, we agree that we are richer for having gone through the learning process and will carry this knowledge with us in our careers and beyond.

APPENDIX A. REFERENCES

Xiuli, Lin, et al. “Study on Principle of Product Defect Identification.” *Procedia Engineering*, Elsevier, 5 Oct. 2012, www.sciencedirect.com/science/article/pii/S1877705812030792