University of Nevada, Reno
Computer Science and Engineering

Virtual Reality Physics Lab

Project Part 4: Project Prototype

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2 Abstract

Outlined in this document is the progress made by Team 10 in their Virtual Reality Physics Lab project. The objectives and functionality of the prototype are given first to describe the intent of the project. Proof of the developed prototype is given second, with summaries of demonstrations and respective feedback given third. The goal of Team 10's VR Physics Lab is to provide students with personalized, immersive, entertaining, and educational experiences that foster student desire to learn more. Few of the educational games on the market meet these goals while also utilizing the latest technologies. Additionally, Team 10's VR Lab will address all forms of VARK learning while garnering student interest in STEM fields.

3 Introduction

To reiterate, the goal of Team 10's Virtual Reality Physics Lab is to encourage learning in a fun environment using the latest technologies. The VR Lab would utilize the HTC Vive and its ability to render realistic environments as a means to provide visual, aural, reading/writing, and kinesthetic methods of teaching. Educational information would be provided using these methods in the form of a game with incentives for the student to improve on scores or complete a level. Previously, Team 10 had completed a majority of the functionality needed to achieve these goals. Going into the prototype, Team 10 had to consider more of the game aspects and make some adjustments to what they had.

Very few design changes needed to be made between planning and prototyping for this project. Any major changes appear in the form of additions, which were not heavily planned but later incorporated in the project for the sake of immersion. Graphical user interfaces that were described in previous projects were implemented, with minor tweaks for readability and immersion. An additional spherical object with physical properties was introduced along with the cube to demonstrate that in game objects are able to interact with each other.

In response to feedback from advisors a setting was added to the prototype to make the environment feel more like a game. Comparisons are shown in Appendix I, with both photos displaying the same functionality. Furthermore, Team 10 highlights the additional planned changes they have been considering later in this document.

4 Establish Prototype Objectives

The main concept behind this project is a virtual reality game in which a user can become immersed in the game and the world while also still learning about a multitude of physics concepts. The development process of the game is planned to go through a typical cycle with a prototype, alpha, beta, and finally a completed product. The prototype plan ensures that most of the basic functionality and mechanics within the game will be completed. In preparing for the prototype demo, Team 10 planned to make sure that certain use cases were met that had been established in prior reports. These included some Tier 1 requirements as well as Tier 2 requirements. The objectives were outlined as follows:

- Create a world where the user can move around freely.
- Construct different objects that can be loaded into the world and allow for the user to interact with the objects.
- Make sure the world has realistic physics being applied to objects and the user.
- Create a screen in which data is displayed to the user. This data will display certain physics concepts such as height and velocity that is is correlated to the specific object the user is interacting with.
- Create a menu screen (user interface) that the user can interact with to begin the simulation.
- Objects will spawn into the world exactly when the user begins the simulation.
- The user will be able to teleport around the world by pointing to a destination with controller.

5 Prototype Functionality

Main Features Implemented:

1. VR headset & VR controllers implementation
    a. To ensure that the virtual reality component was at least started and tested, Team 10 implemented the HTC Vive headset and controllers interaction with the worldspace. A user is able to look around in all directions and the handheld controllers are also correctly displayed and tracked in the simulation. Also included in this implementation is the playspace that the user can walk around in in VR. Early testing of this component and tweaking can ensure that VR sickness is reduced in later versions of the project.
2. Object interaction
    a. The whole point of Team 10's project is to be able to test and play with physics objects in a virtual reality simulation/game - which requires object interaction at its core. This functionality would need to be implemented almost immediately to start working and testing other not-yet-implemented or alpha features of the project.

3. Teleportation
    a. Following the implementation of the abilities to look around, move within the playspace, and interact with objects, the team implemented movement through the worldspace of the simulation. To be able to move freely around the entire level and look at different perspectives while developing and shaping the level is near priceless, hence Team 10's early implementation of teleportation. Another reason Team 10 decided to get this working early was the possibility of VR sickness that can occur during and after teleportation, something the team will have to work on and fine-tune in later versions.
4. Object properties readout (height and velocity)
    a. For both debugging and showing the user feedback, the object properties needed to be displayed as numerical values that would update in real-time with the status of the object - both the current height and velocity applied on the object. These values would have to be displayed in-game to accurately test physics and tweak other features implemented in the near future.

Main Features not Implemented:

1. Cannon for launching objects
    a. Our end product will have a cannon to expel objects at a high rate of speed to show projectile motion. However, for the initial prototype Team 10 felt this was not a priority as it should be simple to construct and hard to code but will not work without the other already implemented items - the user needs to be able to interact with the world, look around, and move before he/she can begin to start the game/simulation. In this sense the team figured it would be better to get the base functionality that would allow them to debug and test the cannon within VR.
2. Level detail and environment creation
    a. This was a no-brainer not to implement. Looks come after functionality in terms of showing off a prototype. While the level does look quite plain and simple, this allows quick load times and easier testing with the lower quality hardware the team initially was working with. Additionally, how the shaders, colors, and environment would all be are subject to change as Team 10 begins creating and structuring more of the game/simulation.
3. Game Objectives
    a. One of the least important items on Team 10's list was the game objectives. As this was just a prototype, huge functionality was not expected to be working and throwing extra resources to get some objectives for the player at this stage of the project would be a waste. There is still some adjustment and refactoring of objectives that will commence as the prototype evolves into a more finished product.

4. Menu UI
    a. This is a significant item as most of the level selection and configuration of the playspace will be done through a menu user interface of some fashion. Currently, Team 10 does not have any other levels or additional configuration options that would warrant the team spending time and resources developing a menu for the prototype and as such it was not included in the initial build of the project for this semester.

6 Develop Prototype

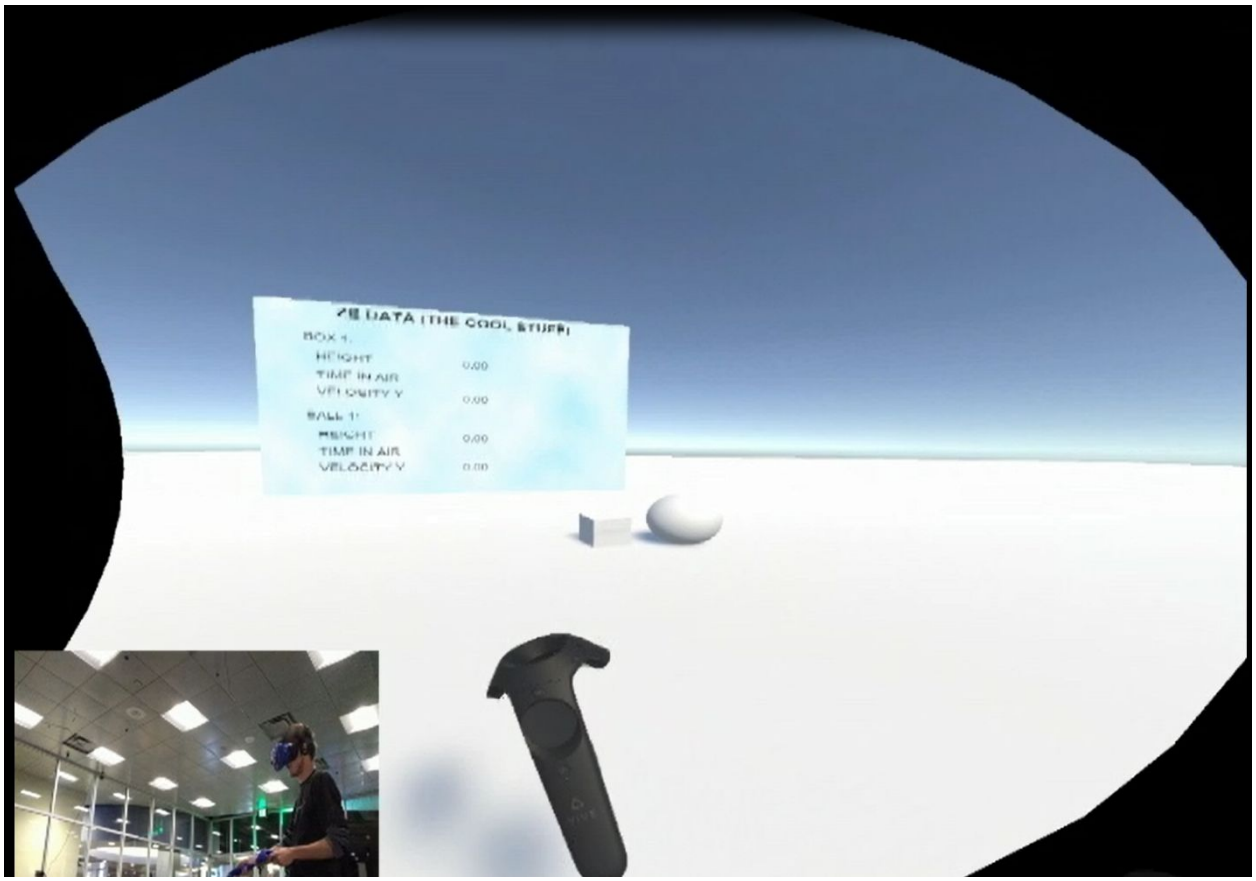

Figure 1: HTC Vive VR headset and controller implementation. In this figure, it can be seen that Chris is looking through the headset at the environment and the controller is displaying properly.

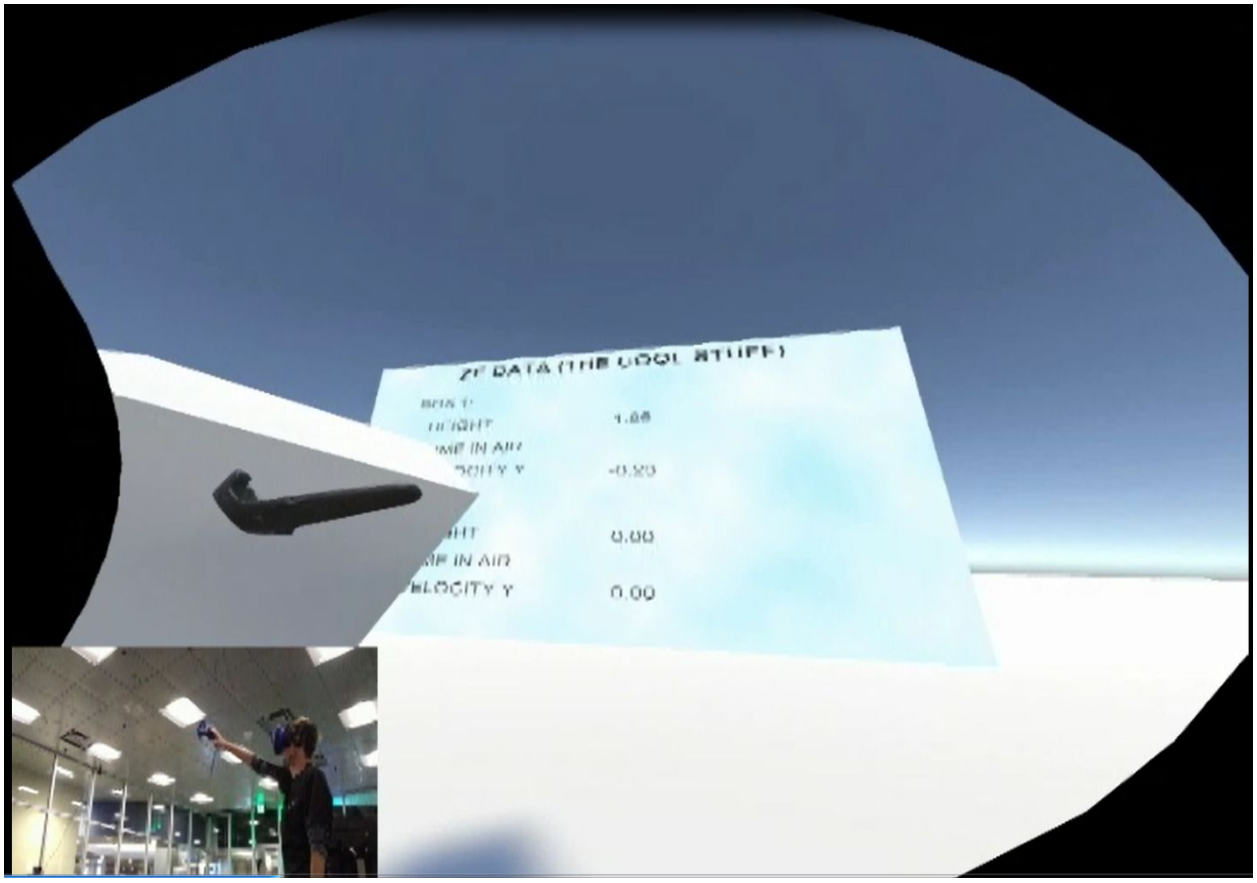

Figure 2: Object interaction. In this figure, there is an object being held by Chris and manipulated to show object interaction and that the object properties on the board are being updated in real time.

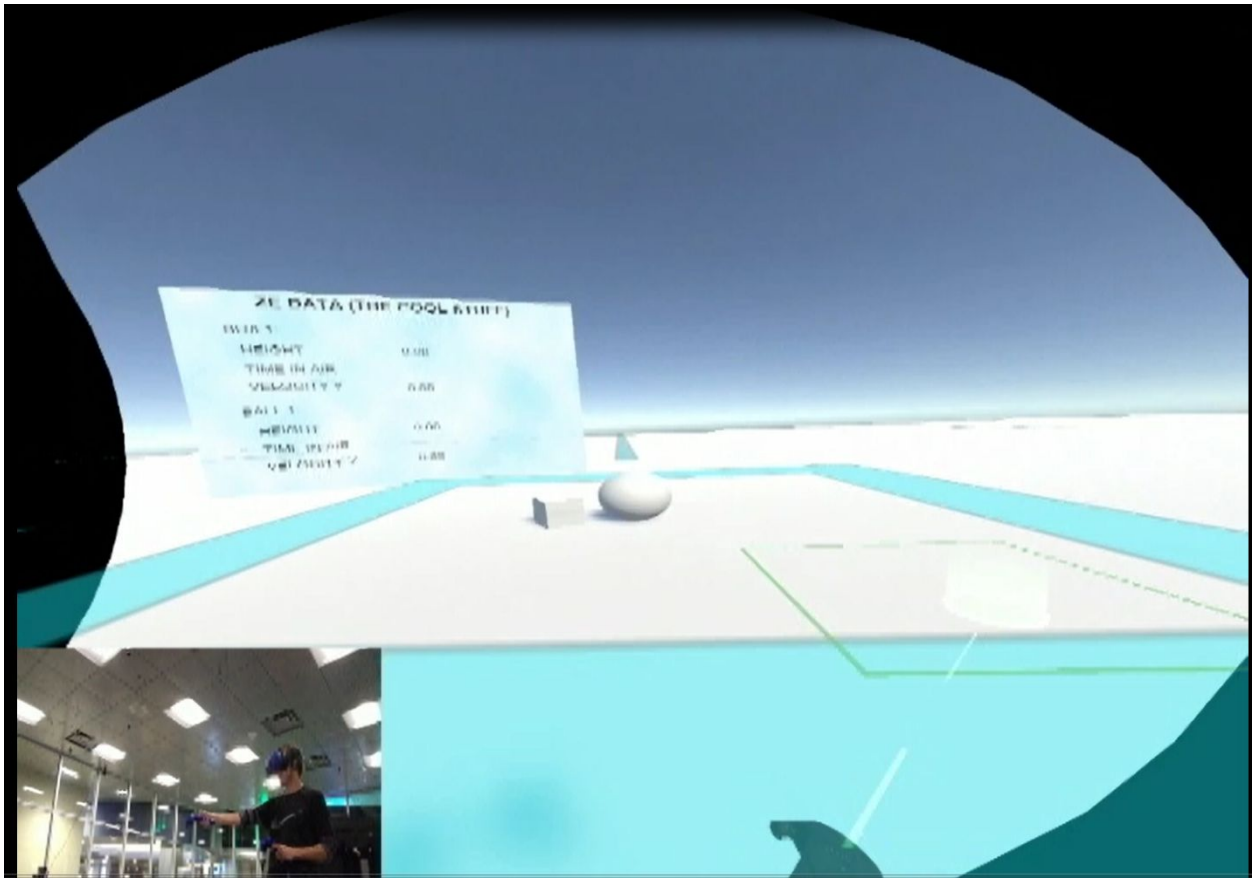

Figure 3: Teleportation. In this figure, Chris is about to teleport inside the location surrounded by the blue box and onto the location he is pointing at near the bottom right with the slightly darker and smaller square that is projected from his VR controller.

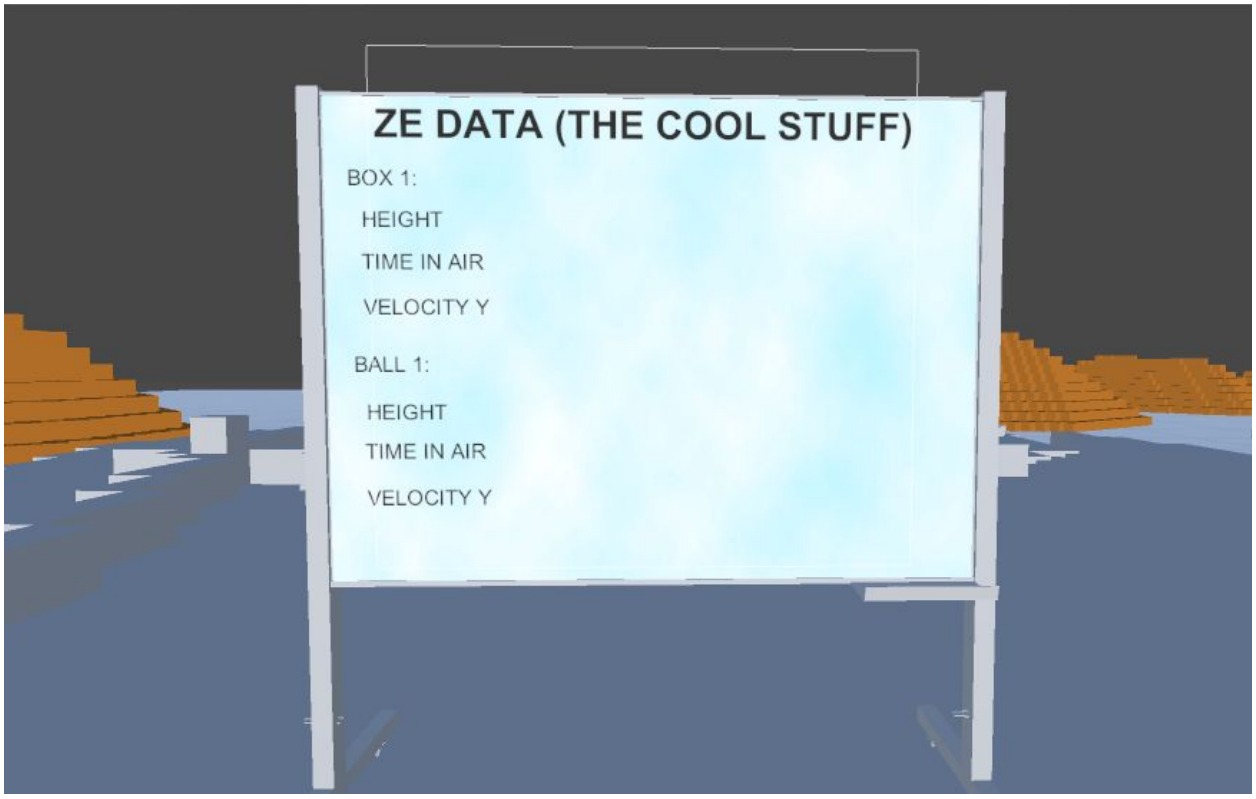

Figure 4: Object properties display board. This is where the data is displayed for each of the objects currently in the world (the box and the ball are the only ones implemented at the moment). The data presented is the exact same as shown in Figure 2; the objects shown, however, are “post-demo”.

7 Evaluate Prototype

For this project it was important to present the VR Lab project to two stakeholders. Team 10 decided to present to Connor Scully-Allison and Benjamin Brown. Due to the time constraint of an early demo date, the team had the user feedback sessions after their demo. Below are the comments and suggestions from both stakeholders.

Connor:

Connor mentioned that the first issue he noticed was that the graphics could be better. He elaborated on this point by saying everything was white and needed textures and/or more environment to the background. Having not very great graphics led to the prototype being very dull and boring. Next he said the teleportation was okay and also the whiteboard (which displays data) would be better if there was units to display the data, in example, meters per second squared. The one component Connor did enjoy was the object interaction, mentioning that it was “pretty cool.”

After evaluating the demo he gave some suggestions. The first suggestion was that there should be some sense of direction for the player. This could be done via objectives and also maybe using another board to display those objectives. Another thing he suggested was having the ability to save/load a game. When asked how it should be done he responded, “Try to look for a saving library in Unity first before writing your own.”

Ben:

Ben attended Team 10’s presentation as a guest and witnessed the demo in person. His first comment was that the presentation “went okay” and further went on to say that the overall experience was barebones. The barebones aspects ranged from the environment to the overall functionality of the project. A couple of points he made was that the teleportation was “jumpy” and a point of reference for the player would have been much better.

After the presentation the team went to work on an environment which was later shown to Ben. His reaction was that the overall appearance was better. This led into a discussion about possible improvements for the project. An updated, “post-demo” version can be found in Appendix I.

Ben mentioned some things the team could think about later. To give the game more visual promise he mentioned going with a “planet” approach to the game when doing the gamification. This would include having exoplanets (each location being a level) and having this be the basis of difficulty. Exoplanets would help with creativity and also make the game engaging for the audience (given the target audience is middle school and high school students). Ben suggested also adding role playing elements where the player can unlock power-ups for themselves using points in the game. The possible updates ended with the suggestion to add a virtual calculator to help students with calculations.

Overall the feedback received about the product was very helpful and will provide use later on in the project. Having an updated user interface and an engaging world combined will allow the player to enjoy the experience as much as possible. By March 2018 these suggestions will be implemented so that a more stable demo can be presented.

8 Demo Prototype

Date: December, 5th 2017
Time: 10:30pm

Feedback:
During the presentation the feedback Team 10 received was not what they had hoped to hear. The professor, Sergiu Dascalu, and teaching assistants/graders who evaluated the project were not very satisfied with the result that was presented. Professor Dascalu mentioned that he "expected more of a game" than a tech demonstration and that "the whole world was very empty." The demo could have been much better and the team was told that there would be a ton of work to do between the time of the demo to the next demo date. Team 10 all took this information very seriously, so they started working on an improved version of the prototype (See Appendix I).

9 Changes Needed to Software Design

Based on the prototype evaluation, there are a few changes or updates that need to be made to the game. One of the biggest changes that will occur is with the design of the world and objects. The world will be expanded using the object modeling tool MagicaVoxel, which will change the overall appearance of the world and add terrain. Another change will be with ray casting, where the user will be able to see a highlighted line before they teleport which will indicate the location they would be teleported to. Additionally, experiments will be done with minimizing teleportation drag to reduce the potential of VR sickness.

10 Contributions of Team Members

Listed below are the total working hours each team member contributed to this project. Given below these hours are the specific parts each member worked on for this project prototype. Included in these times is the time spent as a group editing and formatting the final iteration of this paper.

Working hours:

Andrew: 7 hrs.
Cover page, prototype objectives, and changes needed to software design

Chris: 13 hrs.
Evaluated prototype and demonstrated prototype

Nick: 5 hrs.
Prototype functionality and developed prototype

Will: 3 hrs.
Table of contents, abstract, introduction, and contributions of team members

Appendix I:

Shown below (Figure 5) are comparison snapshots of the demo that was presented on December 5th, and a quick fix-up using feedback from stakeholders and Professor Dascalu. The left photo is from December 5th and the photo on the right is from December 7th.

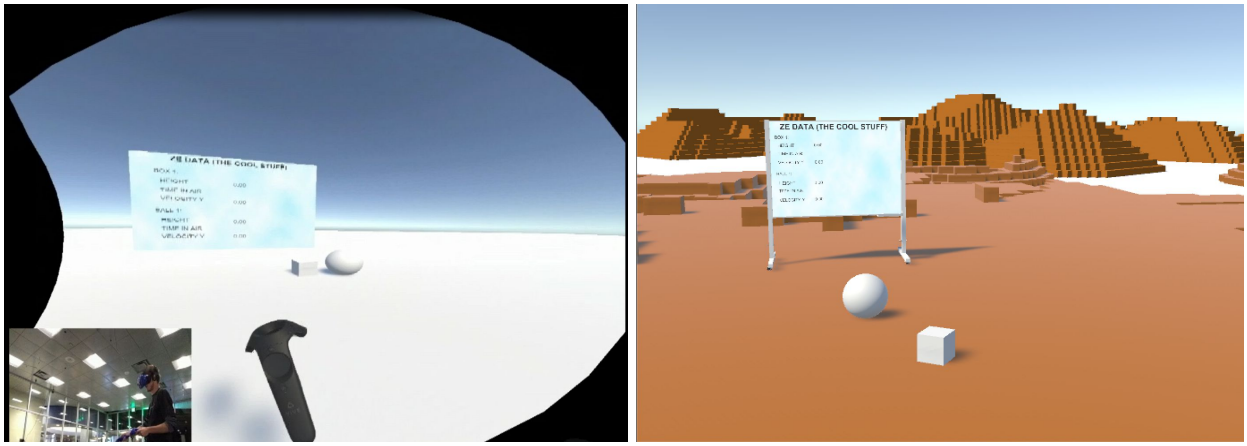

Figure 5: A comparison snapshot of the before and after shots of the demo on December, 5th

Adding in a backdrop helps the world feel more engaging and not as bland as the environment on the left. Another addition the team made was the whiteboard. In the demo we presented the data as a floating board. The feedback was that it felt bland so we decided to add in the whiteboard object which now has data attached to it adding a better aesthetic.