EPFL

CHILI
computer-human interaction
in learning and instruction

LEARN
Center for Learning Sciences

Collaborative Interior Design Workspace in Virtual Reality

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Contents

1 Introduction

As part of my bachelor's degree in computer science at EPFL, we developed a virtual reality collaborative workspace for interior designing using the Unity game engine. This project is carried out within the framework of the CHILI laboratory, based at the school. The CHILI lab develops new interfaces for educational purposes. The members study human-computer interactions to improve learning in multiple domains. They project to increase the use of virtual reality and other computer technologies in the teaching of various fields. The new ideas they develop and their effectiveness is empirically tested in the lab and in real classrooms directly[1]
The main objective of my project is to explore the possibilities the Unity framework allows in terms of developing multiple-party VR software. The main components are:

1. The Mirror module (inspired directly from Unity's UNet deprecated module) for the networking between multiple users.

2. The Oculus Integration module that allows easier development in VR

In that optic, the project has been divided into two great tasks. The first task aims to develop the software necessary to allow an interior designer to showcase his/her work to clients virtually. Subsequently, implementing a strong networking code is necessary. More importantly, developing the software itself for the users is at the core of this project. This includes the editing toolkit for the designers, along with the possibility to remove/add furniture and change the textures. On the other hand, we also have the option to change the scene lighting and adding comments for both designers and clients. The other great task in this project was to port this entire code into VR and make the experience more immersive. This project gains a lot from the VR experience since it introduces elements that we can't have in the real world. For instance, moving furniture with a controller, or painting walls instantly with no extra cost.

[1] https://www.ep .ch/labs/chili/

2 Previous Work

2.1 Garden VR

CHILI lab has already done some work on designing a VR application for supporting gardener students. The research projects done by Kevin Gonyop Kim demonstrate how VR can be used to help the students in design learning. With the Garden VR application, students can design a garden, explore the garden by changing seasons, and growing trees [2]. The current project is another application of VR for the students in another domain, interior design.

2.2 Networking on Unity

The current project is a continuation of a previous semester project done by Yannick Goumaz and takes the advantage of making use of some of the results [1]. The main objective of the previous project was to have a first look at Unity's features, and more particularly the UNet module, which allows multiplayer interactions. The project took advantage of the lower-level API functionalities to implement a part of a bigger project from the CHILI lab, where several Unity users must share messages and design files. It also contained a small 3D multiplayer game using the high-level API. The general purpose of both was to make examples for future projects of the lab which could take advantage of networking or multiplayer, namely this project.

3 Material and Methods

3.1 Selecting a job

At first, the project's goal was to create a collaborative workspace in VR. Therefore, the first task was to decide on a workspace. Our first criteria were that the job had to be acknowledged as a vocational training job by the swiss confederation's state secretariat for education. For this, we consulted the designated website [3]. Additionally, the chosen job had to be a job where we can gain something from VR and being collaborative online. After skimming through the website, we decided that the best 3 jobs to consider were:

1. Commercial employee where we could simulate customer relation.
2. Photographer where we could simulate multiple scenarios and grade how the students decided to take the picture in VR, depending on the settings they used with the camera and the angle they took.
3. Interior designer where we would have designers work on their projects while the clients can watch and add comments.

The commercial employee idea was written off as being boring and tedious to implement. The problem with the photographer's idea is that it is hard to explore the collaborative aspect. Hence, we decided to go for the latter. It gains a lot from the user being in VR and we can use the collaborative aspect to connect the interior designer and his/her clients.

3.2 Importing previous work

As explained in the previous work section, this project was built upon the work of two previous projects. The gardening in VR was only an inspiration for the project. On the other hand, the networking in Unity project contained a solid base that we could build upon. Unfortunately, the UNet API [6] has been deprecated, so we had to do some work, in the beginning, to change the used API to Mirror [5] (another networking API).

After finishing the rework the user had 2 menu screens available to choose from, the first one let him host a new session, whereas the second one is to let him join an existing session with a given IP and port. After this step, the player is spawned in another room and can start interacting with the virtual 3D environment provided to him.

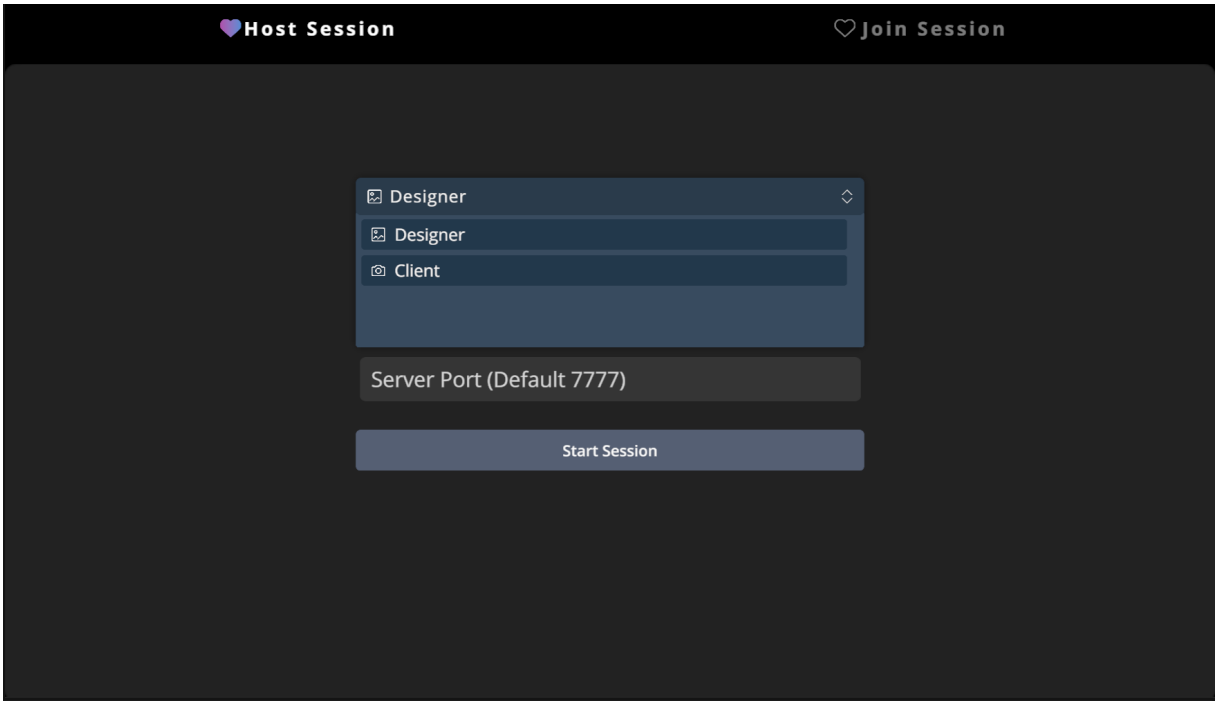

Figure 1: Host menu with the option to host as a designer or a client

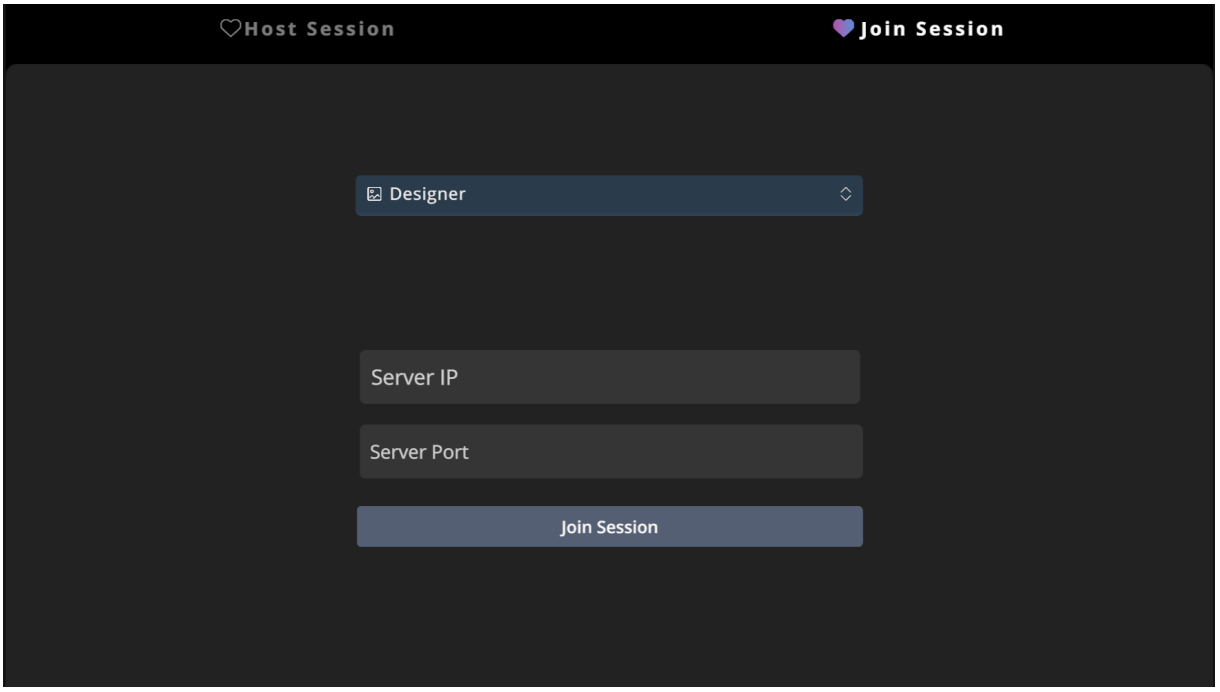

Figure 2: Join menu

3.3 Creating the room

The first step of the project was to create a room where the designer can work. As an initial step, we created a room in Blender. As an extension, we can use a 360 camera and 3D reconstruction to bring the INM 202 room to life. Other ideas are presented as an addition to the project like the possibility to edit the dimensions of the room itself or import the room from a 2D floor plan.

Figure 3: 360 picture of INM 202

Figure 4: 3D reconstruction of INM 202 using LiveMaker [4] (white lines are the mesh edges)

3.4 Tools widget

A core feature to the interior designer is the tools widget. Using this menu, the user can toggle the lighting between 3 options: Morning, afternoon, and night. At first, the lighting was managed by the high-definition render pipeline unity offers. After some consideration, it turns out that this pipeline is costly in terms of CPU power and therefore was slow on the VR headset. Hence, we opted for the more CPU-economic option which is the universal render pipeline that also allows us to manipulate the lighting with relatively good quality.
Another tool provided to the user is to toggle on and off the use of comments that we will discuss later. Finally, using this screen the user can also access the other screens that allow him to import furniture and change the texture of the floor and the walls.

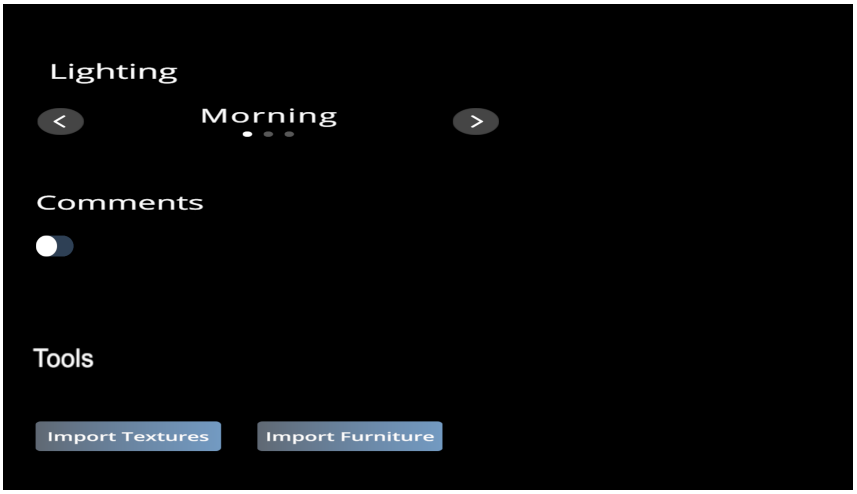

Figure 5: Tools widget menu

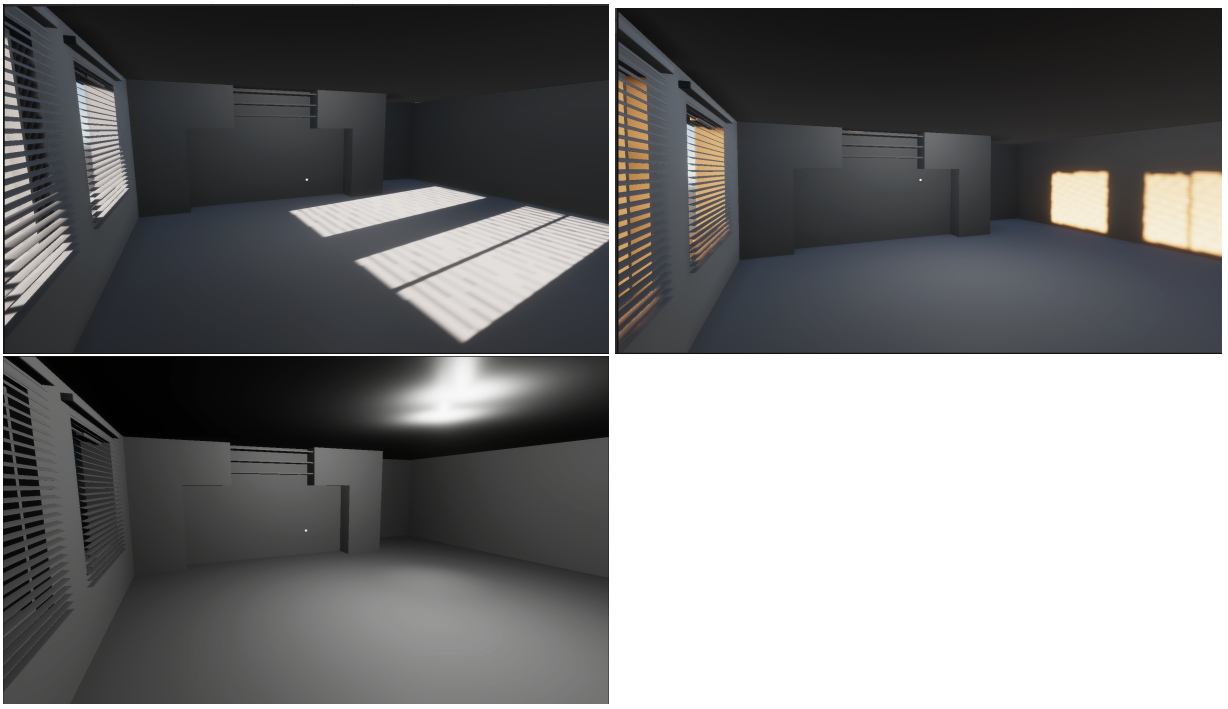

Figure 6: The room in the morning, afternoon, and at night

3.5 Furniture Import

Using the tools widget, we can access the furniture import window. From this window, we can access multiple types of furniture like beds, chairs, tables, and sofas. After selecting a furniture type, we get another page with multiple models from that furniture. These models were found on the internet with a royalty-free license. For real-world use, we can imagine that the software lets the interior designer upload his own 3D furniture assets so that he can use them within the virtual-reality software. There could even be a workshop online where interior designers can exchange the furniture assets they have.

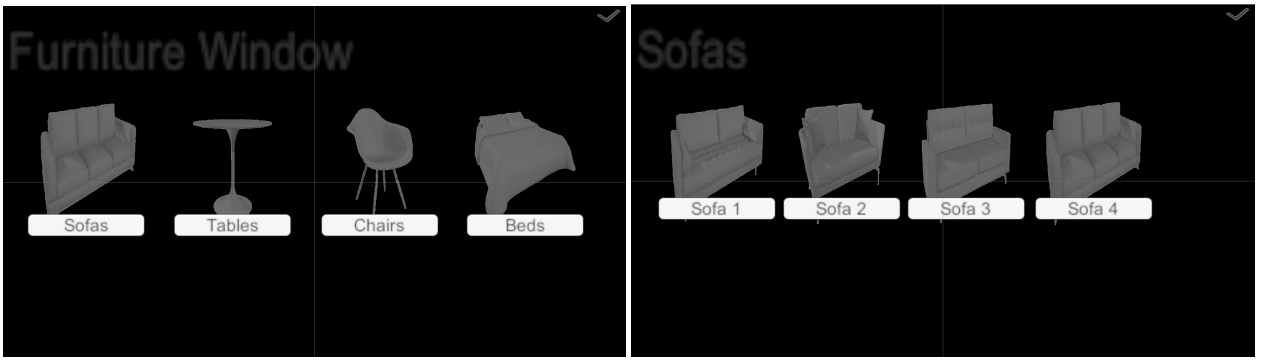

Figure 7: Furniture window along with the sofas widnow

3.6 Texture Change

Also accessible from the tools widget, we have a texture window available to change the texture of the floor and the walls.

Figure 8: Texture window

3.7 Comments & Editing Furniture

After importing the furniture into the scene, we can select it to modify its settings. Using ray-casting, we can detect when the furniture is clicked. After we detect it, a menu appears. This menu lets us see old comments for a particular piece of furniture as well as adding new comments. Adding a comment to the furniture creates a green ball on top of it to signify that there is a notification there. Using the menu, the interior designer can also change the colors of the furniture. This is of course just to showcase the feature, in a more realistic setting, the designer would have a list of textures for the furniture instead of a list of colors. The selected furniture can also be rotated 90 degrees using this menu. This step is crucial for the collaborative aspect of the project. Since the software doesn't support live chatting, this is the only way for a client to communicate his needs with the interior designers. We imagine the user leaving comments on the size or placement or the color of the furniture and then the designer seeing it and deciding if he should address these comments or explain why he decided not to.

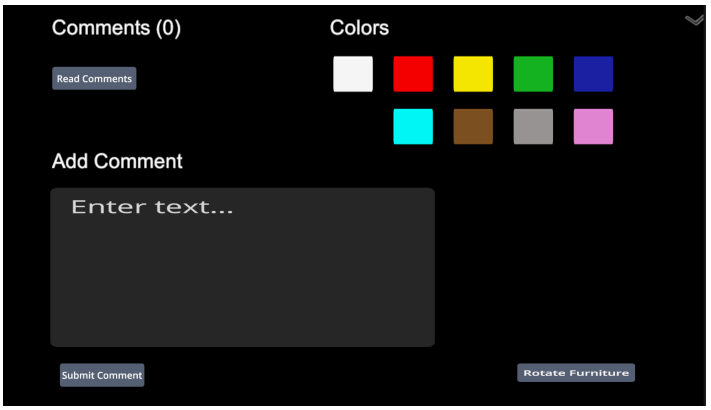

Figure 9: Editing furniture menu.

3.8 Turning everything into VR

Since so far the software is still usable with a keyboard and mouse, we had to do some modifications to include the use of VR. The first step was to import the Oculus Integration module that offers some prefabs to use that already handle most of the VR commands. Unfortunately, this module contained a lot of conflicts with the Mirror module and networking in general. For instance, the prefab for a player in VR contained a camera that was controlled by the headset. Spawning multiple players with multiple cameras in the scene can be very problematic in a networking context since the Mirror module doesn't know which camera to consider as the main camera and bounces forth between the cameras. As a result, we had to re-implement most of the VR prefabs given by the Oculus integration module. Using unity's XR module [7], we were able to detect the input of the headset and the controllers. Using this as an input we were able to reconstruct most of the needed functionalities in VR. On the other hand, we also had to change the entire UI aspect of the project. More specifically, we would have small menus in the scene instead of a big menu that takes up the entire screen.

3.9 Final outcome

By integrating all the functions described above, the final outcome of the application looks as the images below:

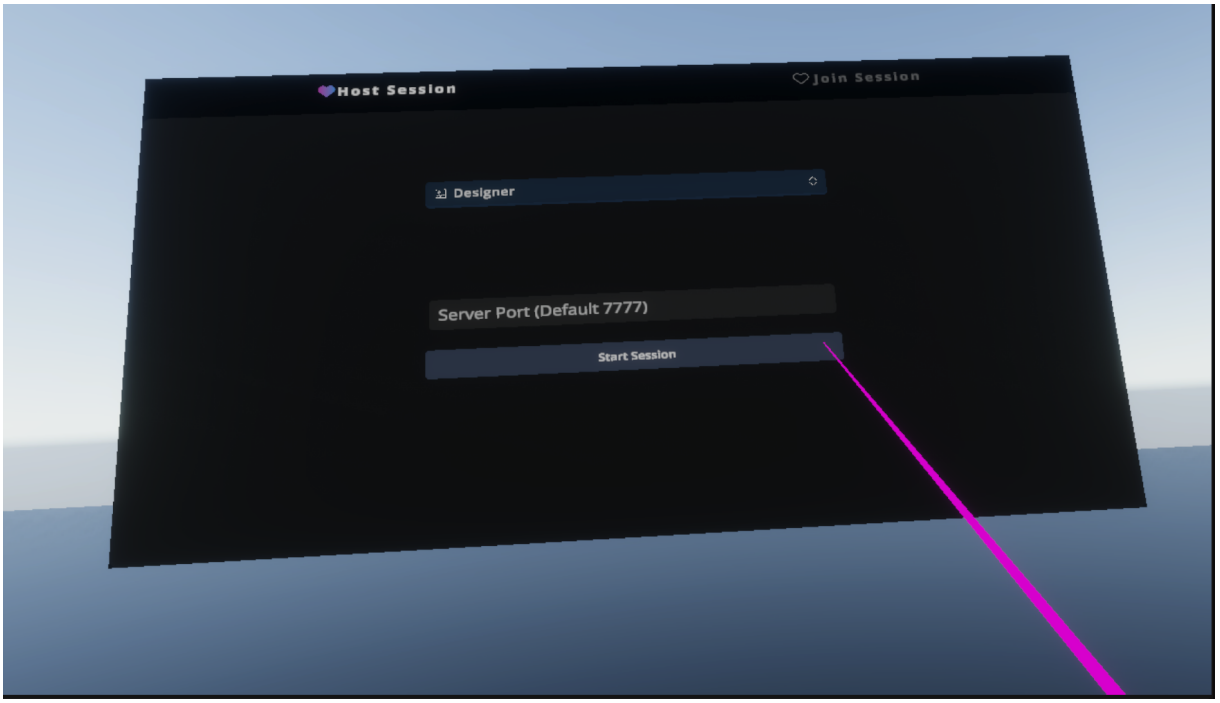

Figure 10: Selecting the session options from the main menu

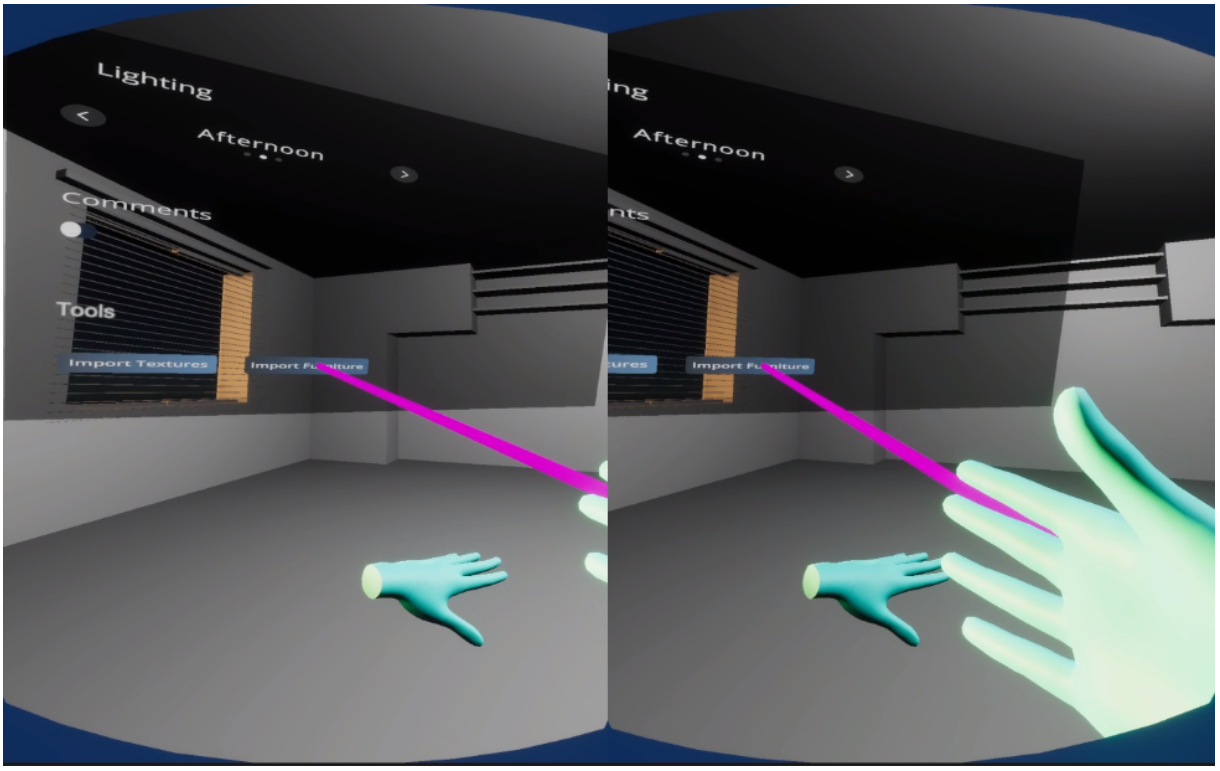

Figure 11: Importing furniture from the VR UI after setting the time to afternoon

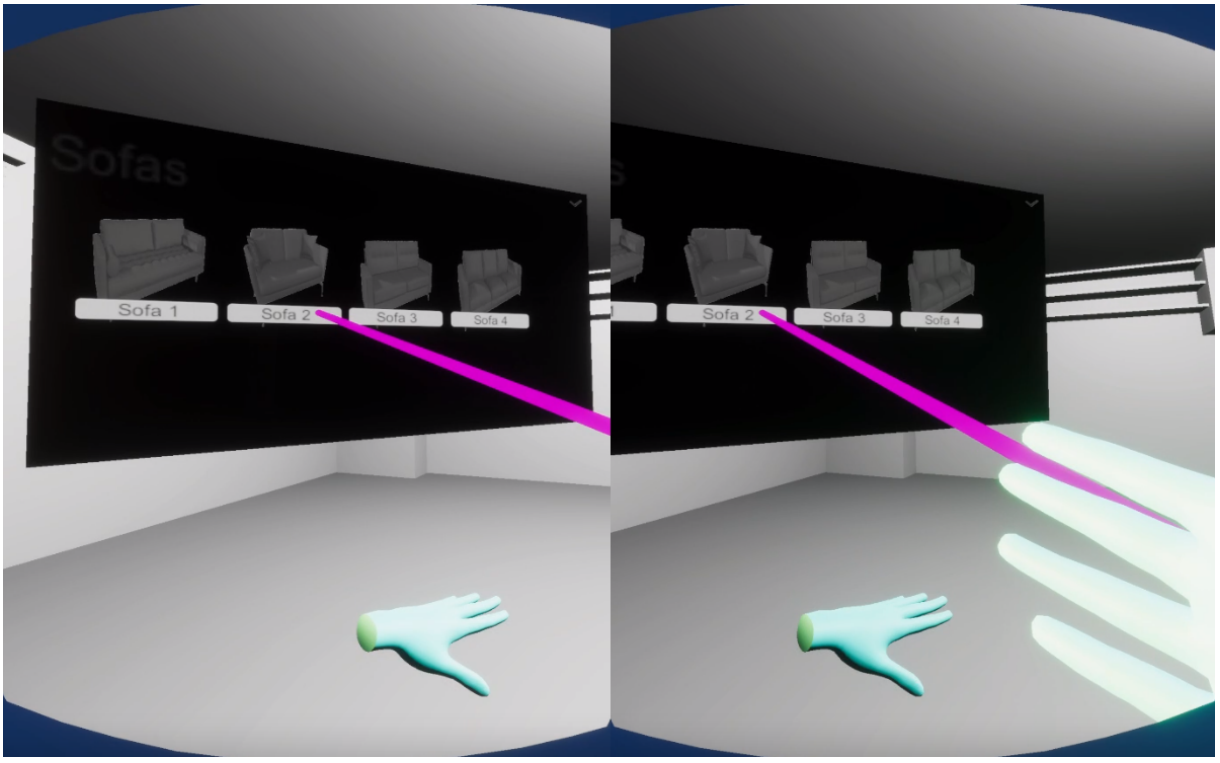

Figure 12: Choosing to put the second sofa

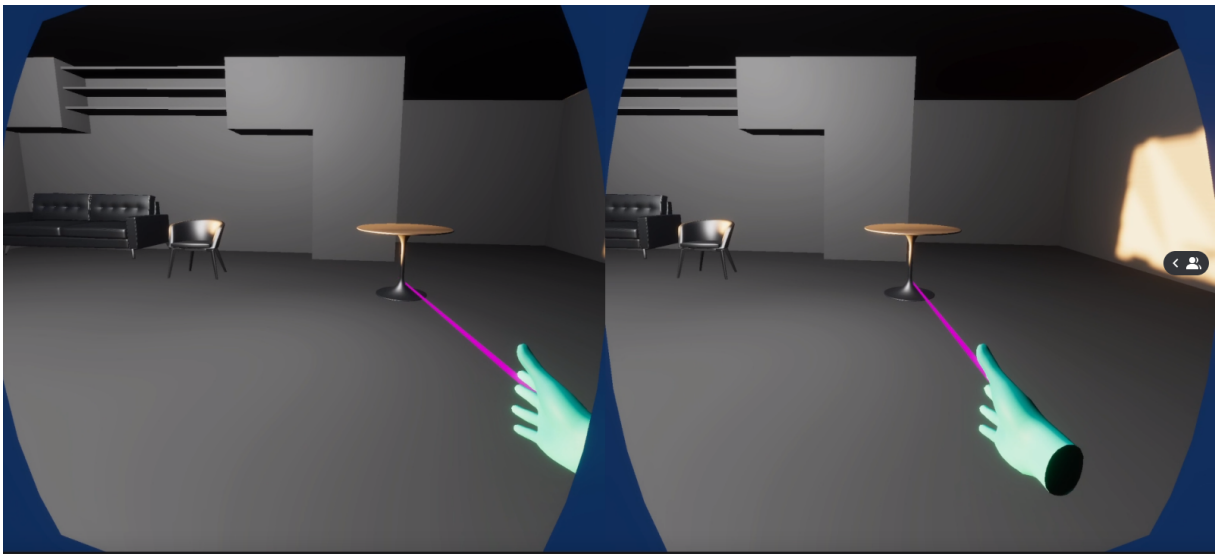

Figure 13: Selecting the table to move it around

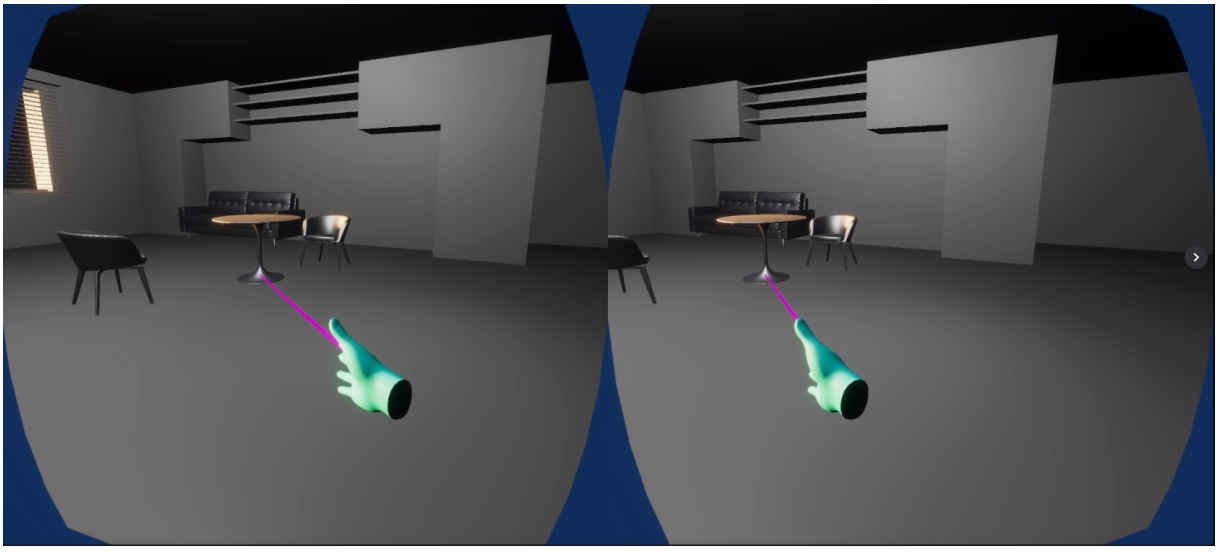

Figure 14: The table has been moved thanks to the raycasting

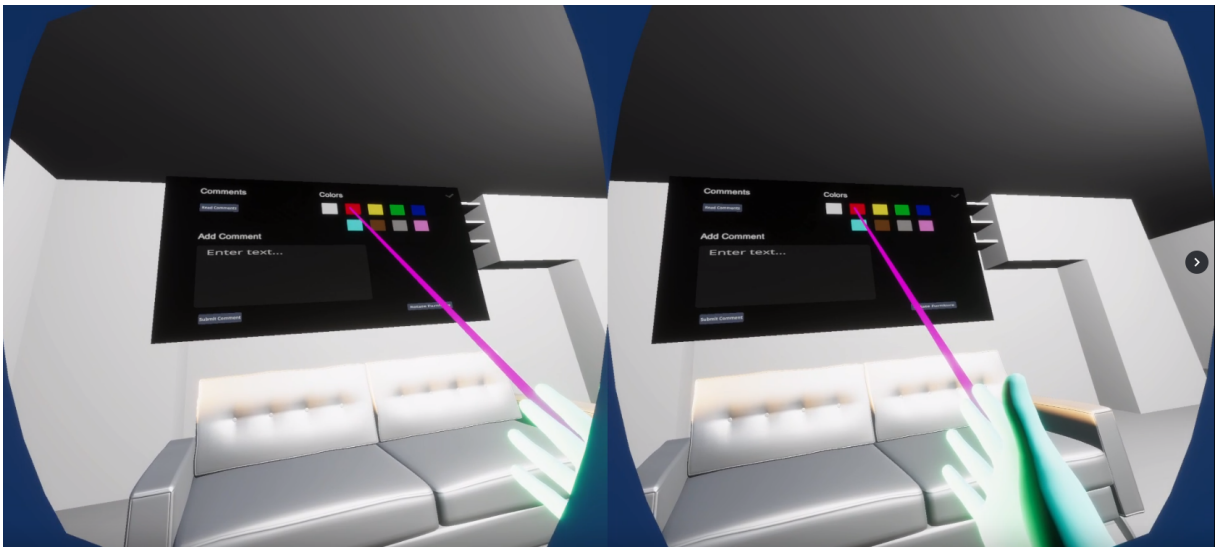

Figure 15: Selecting the furniture editing menu to change the sofa colour

Figure 16: Final design

4 Conclusion

In conclusion, we have successfully demonstrated that creating VR software to teach students interior design using unity is possible. To accentuate the collaborative aspect, the clients can leave comments for the interior designers. Additionally, they can change the lighting of the room to test it in different settings. Likewise, the editors can change the textures of the walls and the floor. They can also place a kit of furniture into the scene and edit its position and color as they wish. This is all being done in a virtual-reality setting so that it is more immersive. Without virtual reality, the students wouldn't be able to move the furniture as much, and they wouldn't be able to change the colors and textures of the scene as much as they would like.

Simultaneously, one can envision future additions to the project to make it more "complete". A first extension can be making the room import more modular. For instance, instead of creating the room in Blender, we can embed a 3D reconstruction system into the software; recreating the desired room with just a few pictures. Furthermore, we can make the room itself customizable inside the software. In other words, we can change the dimensions of the room by pushing the walls or making holes into the walls to create doors and windows. Additionally, to deploy this project into the real world we would have to first do a usability study with real students and determine the key features the student liked and would like to see in the software.

References

[1] Yannick Goumaz. *Networking on Unity*. 2020.

[2] Kevin Gonyop Kim et al. "Using immersive virtual reality to support designing skills in vocational education". In: *British Journal of Educational Technology* 51.6 (2020), pp. 2199–2213.

[3] Swiss State Secretariat for Education. *Vocational Training List*. URL: `https://www.becc.admin.ch/becc/public/bvz/beruf/grundbildungen`.

[4] IMVERSE. *LiveMaker Website*. URL: `https://creators.imverse.com/`.

[5] Mirror. *Mirror Website*. URL: `https://mirror-networking.com`.

[6] Unity. *UNet Documentation*. URL: `https://docs.unity3d.com/Manual/UNet.html`.

[7] Unity. *Unity XR Documentation*. URL: `https://docs.unity3d.com/Manual/XR.html`.