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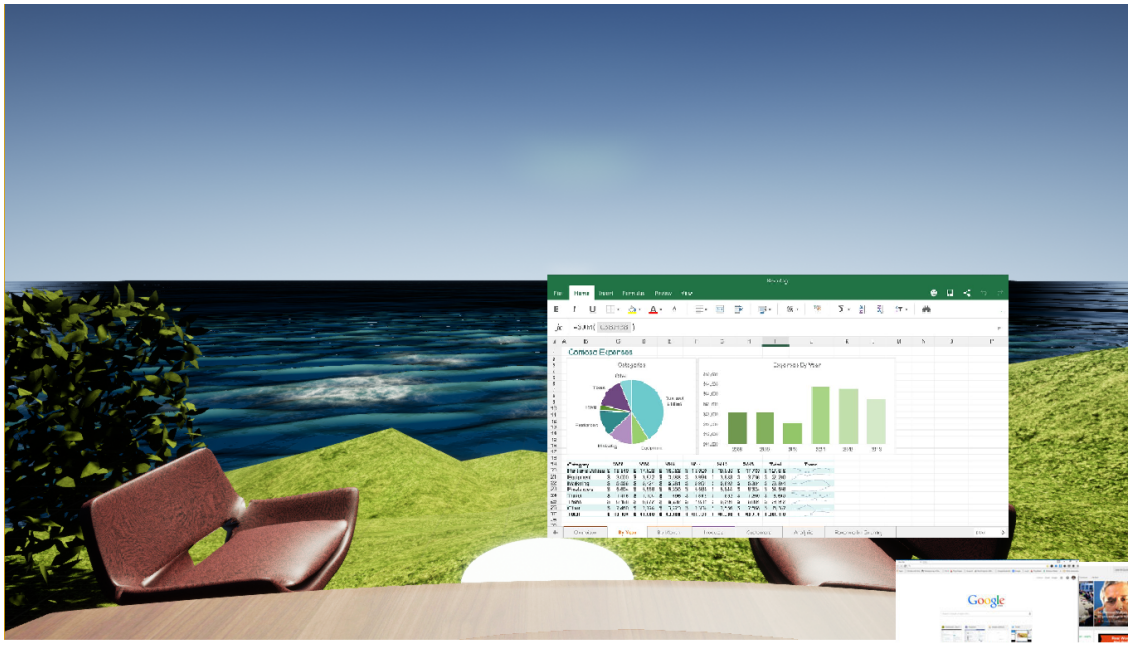

# Personalization in VR and Designing Personalized VR Office Design Tool

Exploring the personalization in VR offices and a preliminary research for designing tool for creating personalized VR offices.

Master's thesis in Interaction Design and Technologies

DAMLA AKYOL

Department of Computer Science and Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
UNIVERSITY OF GOTHENBURG
Gothenburg, Sweden 2018

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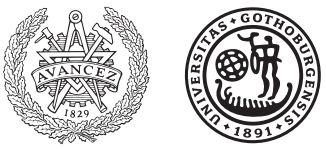

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Supervisor: Daniel Sjölie, Department of Computer Science and Engineering
Examiner: Staffan Björk, Department of Computer Science and Engineering

Master's Thesis 2018:NN
Department of Computer Science and Engineering
Division of Interaction Design
Chalmers University of Technology and University of Gothenburg
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover: A basic VR office prototype overlooking.

Typeset in LaTeX
Gothenburg, Sweden 2018

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# Abstract

Virtual reality environments are recently developing at a fast rate and gaining much attention from many people around the world. One of the possible usages of virtual and augmented reality is with our offices. The offices people use are usually very restrictive and not many people get to say anything about the kind of office they might have. With virtual reality, it is possible to create a whole new environment suitable for the person and improve productivity a lot. One big aspect of virtual reality offices is the personalization. As every person has different characteristics and habits, making the office suit to a person is very essential since they will spend the majority of their daily life in there. However a big problem with creating personalized VR offices is that it requires too much time. In order to decrease the time spent on making these offices, an application that uses standardized assets in order to combine them and create a personalized VR office is decided to be researched and designed.

In order to find which aspects of the VR offices make people feel most in control and feel like the offices are made for them, testings of some basic prototypes of offices are done. After researching and interviewing, three people are chosen to further investigate their habits and office usage, and their desired VR offices are created. With these offices, multiple usability tests are done and importance of location, sounds, and the manipulation of the objects in the offices are found to be the most important aspects. With this information, sketches and prototypes are made for the office creation tool.

# Acknowledgements

I want to thank the main participants of this thesis. Taking time apart with very short notice, allowing me to bother you during your work, supporting me through the not-so-well-done prototypes takes a lot of patience. I learned how and how not to conduct user research and testing through you.

I also want to thank my supervisor, Daniel Sjölie, for sticking with me through this hard year and trying to help me with this thesis. I have been a very distant thesis student and maybe a bit hard to deal with and satisfy, so thank you for the patience too.

And lastly I want to thank my friends and family, and especially my boyfriend. This has been a very tough year for me, and there have been many times that I would not be able to make it, and not just the thesis. Thanks for the support and I definetely would not be able to do this without you.

Damla Akyol, Gothenburg, April 2018

# Contents

# List of Figures

# List of Tables

# 1

# Introduction

Virtual and augmented reality is a topic that many people are starting to get excited about. Currently, the usage of VR can mainly be seen in gaming industry, however some people are enthusiastic about using such technology in their daily lives, mainly their offices. A 2011 game, *Heavy Rain*, has showed a great example for usage of virtual reality in an office setting. One aspect of this example was the freedom to choose how the office felt, which might be what many office workers need.


**Figure 1.1:** Screenshot from the game *Heavy Rain* with the usage of the VR office called *ARI - Added Reality Interface*.

## 1.1 Background

Virtual and augmented reality technologies have many applications in many different fields. It has a good usage in education, specifically with teaching surgery. It has been used in flight industry as a way of teaching how to fly a plane and as a way of simulating emergency situations, and is most used in military pilot training [43]. However the most popular way VR is used so far is in gaming industry, many different examples can be seen with virtual reality gaming, and the VR devices that are affordable and usable by general population have initially been focused on gaming. Recently, the usage of VR and AR technologies can be seen in psychology, mainly as a treatment for PTSD and serious phobias by creating an exposure to the stimuli in a controlled environment, which makes it much safer for both the patient and the

doctor [23][38].

Working in a small cubicle office can be a nightmare. It is very hard for people to get to work in an office that they are satisfied with and even in that case working in the same unchanging confined place years on end is exhausting and eventually leads to lowered mood. Especially with introverts, being in an open office with forced social interactions and constant distractions is sometimes unbearable and leads to a very lowered work performance [18][11]. Virtual reality can help this case a lot. The usage of virtual reality in psychology led to realizing that VR and AR can be used as a way to affect one's perceived environment and form a more desirable accommodation that will in turn possibly enhance one's mood, energy, creativeness, and productivity. Allowing the user to be in an environment that they enjoy being in, while not letting the environment get into their working, may increase productivity [19]. By managing the social interactions in the virtual reality environment, the need of work travels for meetings can be reduced, and collaborative work will not be needed to be done at the same physical place. Virtual reality offices also allow user to manage the external distraction they get, whether be it their phone or e-mail, they can choose to receive a notification or ignore completely depending on the situation and their wishes. Organization of both physical an virtual offices would take almost no time with augmented reality, and the 'virtual privacy' would make the user feel comfortable and safe in their working environment [37].

## 1.2 Initial Project

In the first version of this thesis, another aspect of the VR and AR offices was the project focus. The thesis was being planned on assisting the project BeachHead which was later on submitted to VRST 2017[31].

In virtual reality devices, how the real environment looks and what is happening is not represented enough. When a person is using a head-mounted display, they usually feel like they are completely isolated from their environment. They can not see, and often cannot hear anything that is going on around them, resulting in the lack of communication. When such devices are used, the surroundings should be cleared up too, in order not to bump into the things that the user cannot see. This becomes more important in virtual and holophysical workspaces, as the person using the workspace loses connection with other people.

In order to overcome the mentioned problem, the project BeachHead is established. The BeachHead project works on blending the real world surroundings and objects to the virtual reality in order to create a smooth transition between them for the user. Incorporating real world objects to the virtual environment requires a certain evaluation of the captured object. This is done by generating some point clouds by dividing the space into volumes of interest and evaluating these point clouds and how they should be visualized, which is done using Kinect depth cameras to capture 3D videos of the surrounding objects to further include them in the virtual environ-

ment using Unreal Engine. The aim of this is to minimize the distraction caused by these objects represented by point clouds, while letting the user to interact with the necessary ones to increase awareness.

A similar project was "Incorporating Dynamic Real Objects into Immersive Virtual Environments" by Benjamin Lok ,Samir Naik, Mary Whitton, Frederick P. Brooks Jr.[26] This project's aim is to incorporate real world objects into virtual reality in order to let the user to interact with them. This project also uses collision detection to determine whether these real world objects are colliding with the virtual objects, therefore allowing both of the objects to affect each other. While the goal of 'allowing the user to interact with the real world more freely' is the same, the approach of BeachHead is different; BeachHead aims to create a user controlled environment where the existing virtual reality applications can be executed. In this environment, the real world surroundings of the user is captured and incorporated, and the user has the freedom to design this environment in the way they want, therefore the visibility of the real world objects might be replaced with some other virtual object, or even might be disabled.

The aim of this project was to find out the important aspects of point cloud visualizations that represent a real environment, concerning awareness and non-distraction. For this, some tests with point clouds and different particle effects were done in Unreal Engine, however later on the project was dropped.

## 1.3 Aim

A completely personalized VR office takes a long time to create. The office should be the perfect working place for the user, and it should fit every single one of their needs. Office location, the sounds, the interaction with the environment, handling of the social interactions and inputs, every different aspect should be designed specifically for that certain user's desires and needs. In order to do this, a very deep understanding of the user and how they work is needed. Then, many prototypes, tests, reviews, and iterations of this process are necessary to create an AR/VR office that the user will be happy with. With one single user, this process may take weeks or even months, and doing this commercially may not be feasible as it would also require a very large fee.

In this project, the aspects that users desire in their AR/VR offices in order to feel completely in control and create their own perfect workplace are explored. The aim of this research is to create a toolbox that will help designers, or ambitious users, to create AR/VR offices personalized for the user, using parts of aspects of the environment that are pre-designed through the common desires of the general users. This way, the designing process of the VR office will be much faster as the possibilities of different aspects are already explored and set.

In order to reach this aim, the following questions were in focus during this thesis:

- *What aspects of a VR office environment are important in making people feel like the environment is personalized and made just for themselves?*

Another question was also asked as a supporting idea: *How can an application be used to create personalized VR/AR offices using standardized assets?*.

## 1.4 Related Work

**Virtual Desktop** can be used with HTC Vive, Oculus Rift, and Windows Mixed Reality and it enables user to control their computers with the VR headset and controllers [33]. With these applications users can do everything they can do on a computer, using voice commands, keyboard and mouse when necessary, and would not be limited to a single monitor. The application still is just the computer and does not create a virtual office, rather using the computer in a very large display in a virtual environment.

**Figure 1.2:** Screenshots from the Virtual Desktop application.

**Think Space** enables users to create whiteboards and interact with them collaboratively. The users are represented with avatars, can move around in the environment that is either a beach or a desert, can draw on the whiteboard simultaneously, and have voice chat. It is a very nice application for brainstorming or small meetings when the participants are in physically remote places.

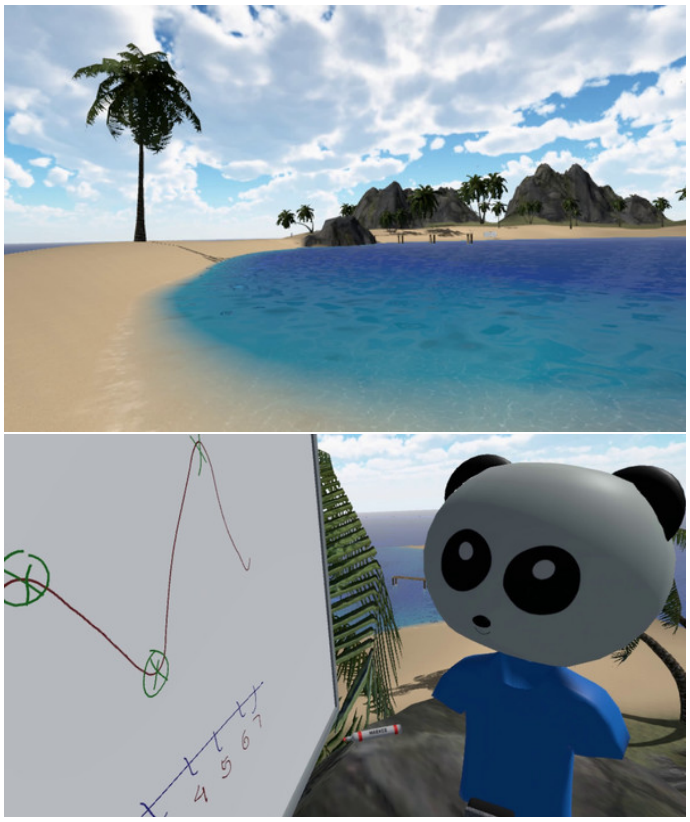


**Figure 1.3:** Screenshots from the Think Space application.

It is a very minimal application, however it is not suitable for professional meetings as the avatars are cute little animals. The interaction is limited only to whiteboards and the movement can be done via teleportation making it even less immersive, but even in this state many users report using this application when they are whiteboarding or brainstorming alone, as seeing a giant whiteboard and having infinite amount of whiteboards help the users run their ideas faster, and eventually make it much easier sending to other people [32].

**Studierstube** is presented in the article '"Studierstube" An Environment for Collaboration in Augmented Reality'[36]. In this application, multiple users in one room work with 3D display of computer-generated data, wearing special see-through tracked glasses which, while providing the spatially aligned information, allow to choose the viewpoint individually and maintain usual atmosphere in terms of talking to colleagues and natural interaction in general, simultaneously allowing to move freely. This work combined two fields, Augmented Reality and Scientific visualization, since authors mostly focus on adding information to the real world physical models in order to make the working atmosphere more intuitive and simple compared to working in purely virtual environment, especially in case of multiple people working with the same object. At the same time, certain details of the visual representation can be personalized according to each collaborator's preferences.

A **solution for remote collaboration while designing vehicles** was created by NCSA and GMD for Caterpillar[25]. The system creates a shared virtual environ-

ment which has people connecting from different sites and having a real-time video and audio communication, while having their position and orientation changed according to their viewpoint. This environment is presented in 3D, with geometric descriptions of various objects such as vehicles, buildings, etc. first read from the file and then updated according to the dynamic changes introduced by the users, lastly having video transmissions from users placed at their respective viewpoints.

**Figure 1.4:** Incoming video transmissions are placed at each remote site's viewpoint.

Such usage of distributed virtual reality helps with putting multiple teams from different areas into contact, decreases the production time and increases the product quality. The product can be tested and evaluated prior to creating a final real world prototype.

The article **Augmented Reality Aided Assembly Design and Planning** talks about manual assembly design and, specifically, assembly Product Design and Planning (PDP) and assembly Workplace Design and Planning (WDP)[29]. While PDP focuses on making assembly easier, faster etc., WDP includes workplace design and layout, postural concerns etc. Authors argue that the information flow generally goes only in one way, from PDP processes to the WDP process, and offer to bridge this gap with two-prong approach. First is to provide immersive and intuitive environment for engineers to design and plan the assembly using AR techniques systematically, and the second is to introduce the opposite information flow - from WDP to PDP - in order to help the designers use the real workstation information to their advantage. Head-mounted display would provide visualization while video camera would capture the real assembly scene, and engineers would be able to manipulate virtual prototypes on the real workstation. A manipulation like this would aid design process while using a headset, for example in a VR office.

Hirokazu Kato and Mark Billinghurst present an augmented reality conferencing system in their article **Marker Tracking and HMD Calibration for a Video-**

**based Augmented Reality Conferencing System**[21]. Perhaps somewhat similarly to the previously mentioned project by NCSA and GMD, here remote collaborators are represented by virtual monitors, which can be located in any position relative to user in space, however here overlaying real world and not a 3D environment. This overlay is seen through an AR headset and created using QR cards, the participants representations being on the cards. Also the participants can cooperate by viewing and editing objects together using a virtual whiteboard. The idea here is not to change the environment a lot in order not to disrupt the way people usually work, but to allow users to interact with real world while also enabling collaboration anywhere in the workplace.

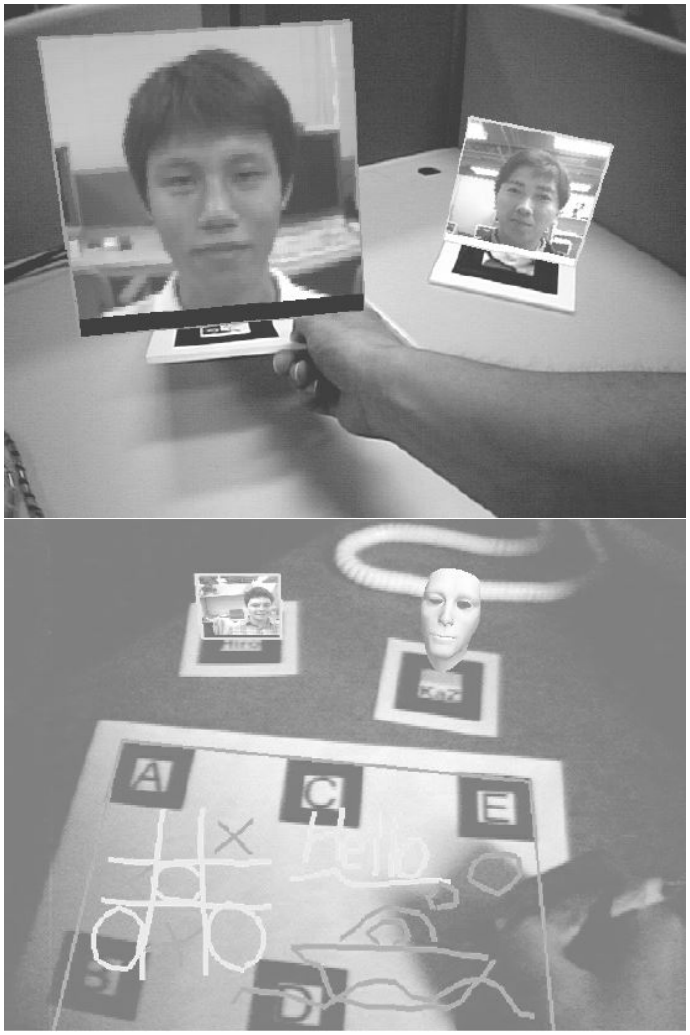



**Figure 1.5:** Remote user representation in the AR interface(left) and Virtual Shared White Board(right).

# 2
# Theory

## 2.1 Tangible Interaction

Tangible interaction generally refers to usage of physical representations of various interactions and objects of a software user interface. The user can physically interact with digital data as the information has physical properties in tangible user interfaces. However, one aspect that usually gets ignored with tangible interaction is interacting with whole body[13]. By including tangible interaction, the user can be allowed to use their full body, their movements and gestures to interact with the design, without the need of an extra user interface. This does not mean that such interaction completely replaces user interfaces, but gives the user the ability to use more natural and intuitive movements to perform actions in certain software and not be limited to the keyboard/mouse set to perform some actions that are complicated or represented in a very limited way.

Tangible interaction is an important aspect to this project, as the interaction between the object(information) and the user inside the virtual reality is done with gestures or possibly with manipulation of the object. Even though these actions are done via the VR control devices such as Oculus Rift controller, when a person is using a head mounted display, they treat the object in the display as they are actually around them, and when the virtual hands reach out to an object it is their own hands reaching out. This creates a more immersive environment that the users can move around and use their own preferred movements to interact with the environment.

## 2.2 Calm Technology

In addition to UI design, design of the interaction is very important for a product. When a UI is being designed, various UI aspects of an artifact such as the color, location, alignment are considered, however one very important thing is sometimes being missed; is the artifact really necessary in the UI, or a better and less intrusive alternative can be found? This is where calm technology principles come into play.

Calm technology has seven general principles[2].

- Technology should require the smallest possible amount of attention - the information relayed should not make the user stop what they are doing and pay attention to the information; it should be ambient.

- Technology should inform and create calm - the information relayed should only be what is currently useful for the user, the user should not dig through the information to find what is necessary, they have better things to do.
- Technology should make use of the periphery - the information should be moving from the center of attention to periphery by user's choice and the user should be able to choose to have the information or ignore it.
- Technology should amplify the best of technology and the best of humanity - both the machines and humans have their pros and cons, technology should be used to emphasize the pros and minimize the cons.
- Technology can communicate, but doesn't need to speak - the information can be conveyed in many different ways, not just by voice.
- Technology should work even when it fails - technology should not completely break down and not cause huge problems for the user. There should be a restore point, backup, or default state in case of failure.
- The right amount of technology is the minimum needed to solve the problem - more information and more technology is not always better, an asset should be implemented only if it is really necessary.
- Technology should respect social norms - new technological advancements are not always welcome within the society. In order for the people to accept, the technology should not break down norms.

Keeping the information around the periphery of the user and letting the user focus on the information, rather than forcing the information on their center of attention, is a very important aspect of a VR/AR office. The user should be the one to decide on the intrusiveness and the importance of the information, therefore they should have the option to completely ignore it[45]. However, this does not mean that the information should be hidden; on the contrary, it should be very easy to recognize and understand what is going on, but the attention that should be given to the information can be changed.

## 2.3 Research Through Design

Research and design are usually considered as two separate actions. Research, which involves observation, analysis, interview etc., is done in order to conclude to a solution, and eventually design that solution. In research through design, these two concepts are not completely independent from each other. Design process itself sometimes becomes a source of knowledge, which in turn provides information to research. User tests on prototypes may result with interactions and usage of the prototype that was not thought of before. The results of these user tests take parts in both improving the next iteration of the prototype, and in discovering new concepts and usages in this design.[34]

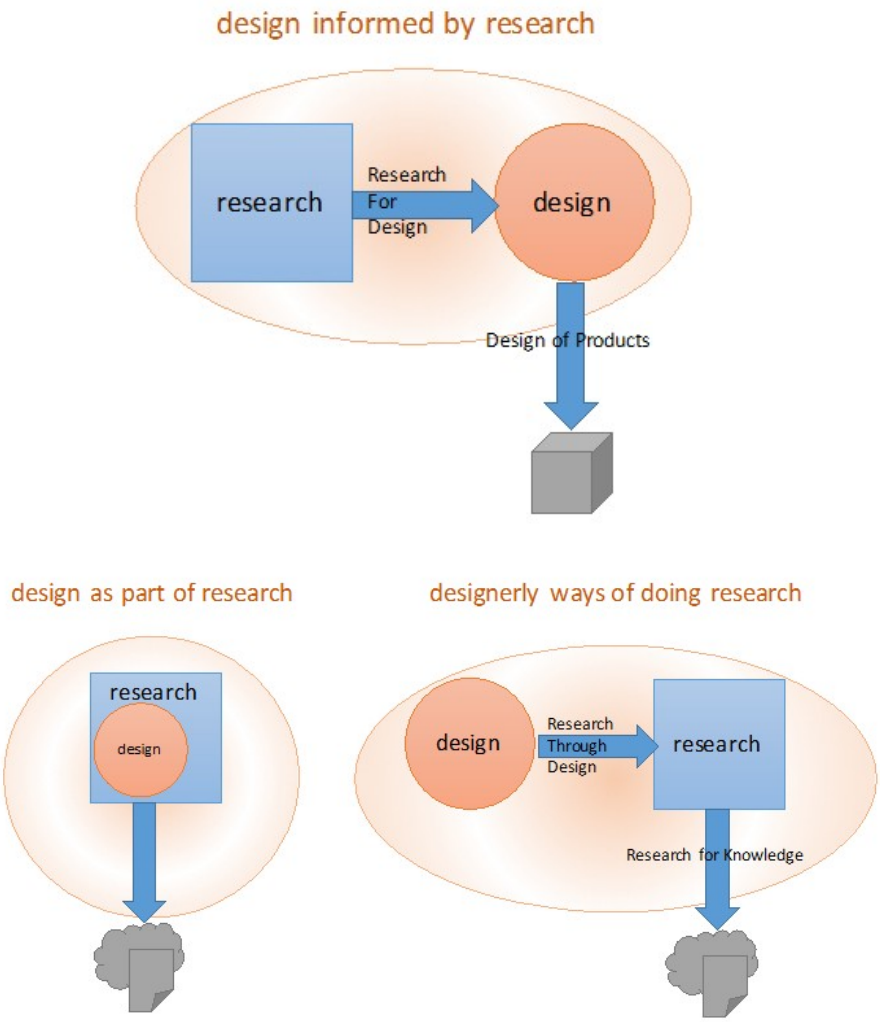



**Figure 2.1:** Design formed by research, designerly ways of contributing to research (left) and doing research (right) [34].

In this project, research through design can clearly be seen. The design for the personalized VR office tool required intensive research of the users' wishes on their VR offices. In order to get these information, interviews, observations, prototypes, and user tests had to be done. The expected results of these designs cannot be predicted unlike a scientific test, only observation of the results can be done. Design process of virtual reality offices and their tests gave results for the researching of the VR office usages, and eventually is used as the main research of the design process of the personalized VR office tool.

## 2.4 User Centered Design

User Centered Design is the process of designing with putting the user at the center of the design and focusing on the users' desires, requirements, and feedback. User centered design emerged from human centered design, however there is a clear dis-

tinction between them; user centered design focuses on the target users of a design, not the human characteristics in general[20].
When a product is being designed, the designer cannot assume that the target users will find a way to use their product because they believe their design is good. The product should be designed around a user. User research is a very important step in user centered design as it can show the designer the most necessary aspects of the future product, what the users are expecting from it, and how the user can be satisfied. With user centered design, different prototypes and usability tests should be made too, in order to find the flaws in the design and fix them according to the users' desires and comfort.

The users in user centered design are constantly involved in the process. There are some general phases of the user centered design, however depending on the designer's needs there can be many variations of the process with different phases and combination of the phases performed at different times. The phases include defining the target user and finding how and why they will use the product, finding the users' desires and goals as well as other requirements, create some solutions, and evaluation[42].

## 2.5 Control Over Work Environment

In a 1989 research, the participants were asked to list some aspects of the workplace as inhibitors and facilitators, and the results were categorized into social interactions (which refers to support and relationship with the organization), physical & ambient conditions, utilities, information & communication, and workplace experience as to whether the existence or nonexistence are facilitators or inhibitors[6]. For example, when considering utilities, good furniture and equipment are considered as facilitators in 11 responses while poor furniture and equipment are considered as inhibitors in 3 responses. In this research, distraction was listed as an inhibitor in 44% of the participants, with subsections being quiet/noisy, no interruption/interruption, no distraction/distraction, and no chatting/chatting, and in only 5 responses quiet was considered to be a facilitator and in 18 responses noisy was considered to be an inhibitor, which also is in the most responses in the questionnaire. We can see that the existence of distracting agents are almost always considered to be an inhibitor rather than nonexistence of them being facilitators. Another result from this research shows that private space and the existence of privacy are listed as facilitators, and lack of privacy is listed as inhibitor, while having an open plan workspace was the preferred one out of open plan/private office choices. Employees desire private areas and are unhappy if they do not have privacy, and they also like the open plan workspaces but they do not like the noise, interruption, and the chatting the open plan workspaces bring.

In the research *Effects of control over office workspace on perceptions of the work environment and work outcomes*, participants from 4 different companies ranging from 7 to 143 people from each were given a questionnaire about various factors in workplaces and correlation to performance and satisfaction. They found that

with the increase of distraction people have decreased levels of satisfaction with their work and increased desire to work alone or in a closed room [24]. It is found that control over the physical work environment greatly affects job satisfaction and group cohesiveness. They argue that providing the office workers with increased levels of control over their individual workspaces may result with increased performance. And finally, it is found that on the contrary to what is expected, working alone or in an enclosed space does not affect the group cohesiveness much.

# 3
# Methodology

## 3.1 Research

### 3.1.1 Naturalistic Observation

Naturalistic observation is a type of research that required observing the subject in their natural habitat, and usually used by psychologists. With this observation, the researcher does not impact the subject in any way. This type of observation has both advantages and disadvantages. It is much more reliable than a lab environment, because the subject encounters natural obstacles and have natural reactions and feelings towards them, which is hard to produce in a lab environment. This also helps the validity of the research since a controlled lab environment might cause some results that are not representing of the real world. Naturalistic observation is a qualitative research and is also very good for ideation, rather than quantitative research. [8]. However this type of research is very hard to reproduce the results and get different reactions to different variables, as the variables are not manipulative and catching the same conditions of the variables might be very hard. It is also very hard to find a representative sample in the research, and is better for ideation rather than testing. [8]

### 3.1.2 Shadowing

Shadowing is very similar to naturalistic observation; they both observe the subject in their natural environment, they do not interfere with subject, and they are both qualitative research in nature. However, shadowing is more in-depth than just observation. It consumes too much time and is not feasible to shadow many subjects at once. Through shadowing the researcher can gather in-depth information about the subject and their actions. Existing behaviours, habits, and how subjects interact with the topic can be observed through shadowing, which lets the researcher form their design to their needs. [4]

### 3.1.3 Interviewing

Interviewing might be the most common method in researching users. It is the easiest way of getting reliable information about users; just asking them about a topic results with valid feedback that cannot be interpreted differently with different points of view. Users' motives, desires, goals, likes and dislikes, and preferences

can be learned through interviewing, but most importantly users' views on certain topics can be explained and understood well through this method [14]. It is the only method that can reliably tell what the user is thinking and wanting, making it the most important method in designing.
The interviews can be fully structured, completely following a set of predefined questions, semi-structured, partially following some predefined questions but asking and requiring different questions and information dependent on the situation or the previous answers given, or unstructured, with a certain topic but no predefined questions. Different types of users, topics, and designs call for different types of interviews. [17]

## 3.2 Ideation

### 3.2.1 Now Wow How Matrix

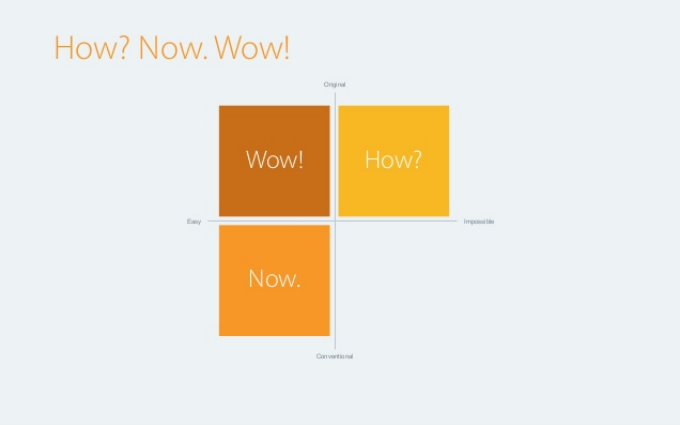



**Figure 3.1:** Now Wow How Matrix.

Also known as Now Wow How Game, in this method the designers draw a horizontal and a vertical line, with the lines showing the possibility to implement and the originality of the ideas[12]. The four sections created by these lines show the ideas that are easy to implement but are normal and might be boring - Now, ideas that are easy to implement and are original and impactful - Wow!, ideas that are very hard or impossible to implement and original - How?, and the ideas that are impossible to implement and unoriginal - Pow. The participants then have post-it notes that they write the ideas on, and then categorize the ideas in the matrix. This helps evaluating the ideas in a very objective way. With this method the participants are also not restricting themselves with the current limits they have and exploring all the possibilities of the design.

### 3.2.2 Brainstorming

Brainstorming is a technique to create ideas while extent, goal and details about a project may not be defined or understood. It is a great way to pop up new ideas

without shutting any out. At the start of a brainstorming session, the goal and the desired outcome should be well defined in order not to go beyond the extent of the project, and waste time and energy on things that are not needed. It is by default assumed that brainstorming sessions are held in a group with or without a moderator, however many people agree that group brainstorming sessions are actually not helpful and solitary brainstorming might be more beneficial.[28] In solitary brainstorming, people do not need to care about other people's egos and try not to say harsh things to hurt them, they can analyze their own ideas and see their extent without being shut down by someone else immediately, and they can go on their own pace and not wear themselves out while producing many ideas. [46]

## 3.3 Creation and Evaluation

### 3.3.1 Sketching

Sketching can be used as a form of note taking, or conveying an idea to another person. While someone is taking notes, it is not always easy to describe what is in their minds through words, so some icons or small pictures might help explaining the idea much easier. They also allow exploring the possibilities and getting a better hold of ideas much faster. It is hard enough as it is trying to understand what you yourself have written and taken notes of few days ago without any sketches that will remind you, and trying to explain this to another person is almost impossible. Every person has different thoughts and imagination so if you try to explain something to them every person will have a different result in mind [22]. Sketches help eliminate this problem as it fleshes out what the main idea is without spending too much time on it. Thankfully, as long as the sketches are somewhat understandable, they do not have to be art pieces. Even some small notes or headings can be used in very bad drawings [27]. The way to sketch is set some time, draw whatever you think of, do not hesitate to go in depth if that place is where your train of thought leads you, and just draw.

### 3.3.2 Prototypes

A prototype, by very basic definition, is a simulation of the final product. It is used to test and see the extent of the possible final product. It is one of the most crucial parts of designing, it helps realizing many issues that might not have been thought of before. The very basic idea can be sketched out, however unless it is made into a prototype the designer cannot see the missing aspects in the design, understand the usability issues, and eventually continue on to refining their design. It can help with new innovations and discoveries, feasibility and usability [1].

Prototypes have some qualities that they are defined by. These are representation which is the form of the prototype, precision which is the fidelity, interactivity which is functionality to the user, and evolution which is the lifecycle [5]. The prototypes can be low fidelity paper prototypes that show the very basic and primitive version

of the final product, or high fidelity fully functioning digital prototype, which is very close to the final product.

### 3.3.3 Usability Testing

Usability testing explores how the user interacts with a design, and how well the design is understandable to the user, and some tasks are usually required by the user to test the design [7]. It can be done with prototypes of different fidelity levels but towards the end of the design process, it requires somewhat working prototypes, and even if the prototype is a paper mockup, it should be able to show the results of users actions and should be understandable. The designer should never interfere with users during usability testing as the user might do an action that were affected by the designer and change what they were originally going to do. It might even be the best if the test conductor does not know the design in order not to affect the tester with gestures or even facial expressions.

Along with prototypes, users tests should be conducted almost at every chance the designer gets during the design process. It allows the designer to detect and understand problems with the design early on, and might provide insights on how the interaction is expected to be by the users.[15]

## 3.4 Technical

### 3.4.1 Unreal Engine

Unreal Engine is a game engine developed by Epic Games. It was released in 1998, and currently it is in its fourth version, Unreal Engine 4. It is used in creating many video games including *BioShock* series, *Borderlands* series, *Dishonored*, *DmC*, *Mass Effect* series, *Fortnite*. It is very customizable and provides the user with every tool needed to create a game, and apart from games it has support to develop many different kinds of applications too. Currently Unreal Engine 4 can be used to create applications and games for Windows, macOS, Linux, SteamOS, HTML5, iOS, Android, Nintendo Switch, PlayStation 4, Xbox One, Magic Leap One, SteamVR/HTC Vive, Oculus Rift, PlayStation VR, Google Daydream, OSVR and Samsung Gear VR[40][41].

### 3.4.2 Gear VR

Gear VR is a VR headset that is developed by Samsung and Oculus collaboration. The headset is manufactured by Samsung, and the software is developed by Oculus. It is used with a Samsung Galaxy smartphone and creates a full virtual reality headset. Gear VR is used with 360 videos and some apps designed for it. There are numerous games that can be played on Gear VR, however the games designed for Oculus Rift cannot be played on it unless there is a specific Gear VR version[10]. GearVR is much more mobile than Oculus Rift or HTC Vive as it is completely

independent from a computer, and the user can move around as much as they would like without being limited to a certain distance, however this also brings limits with the computational power as GearVR can only run through a smartphone, and usage of additional devices such as full body tracking, depth cameras, or leap motion requires more configuration and sometimes is not possible.

## 3.5 Method Selection and Usage of Selected Methods

During the research phase of the project, initially naturalistic observation was used to understand the users and the design space better. This was further on supported by interviews and shadowing. A focus group was considered briefly during this phase. A focus group is simply a group of people discussing the relevant topic, and can be in the form of a group interview. This is very helpful for defining the problem if the target audience is not well known. In our case, the target audience is very well known, and in fact many designers are included in the target audience. One problem with using the focus groups was the fact that the problem was not well noticed, and using VR offices to reduce stress, and increase productivity is considered as an unconventional way to solve the problems that the open offices and monotonous office life brings. A focus group can go out of the desired topic very well, and a technology like VR headsets is still not accepted well by many people and the long term effects are unknown, therefore it is expected that the group interviews will lead to discussions about the usage of headsets and it will be hard to get a good finding about the project in the early stages therefore this is currently not done. However, for exploring the ethical issues and social implications, this method is very suitable and is aimed on being done soon.

Right after user research Now Wow How Matrix is used to determine what the product will be. Instead of Now Wow How Matrix, Six Thinking Hats were considered to be used to further on ideate about the future possibilities and current necessities. Six Thinking Hats method incorporates lots of emotions and optimism to the creative process. It helps the designer focus on what different individuals might think and what the possibilities of the designs might be. There are many parts of VR offices that were not explored in this project, like social interaction, personal notifications and such. This is one method that will definitely be used when the remaining aspects are researched and explored more. However for now it wasn't deemed that beneficial to use this method. Personas and scenarios are other methods for focusing more on the user and their interaction with the design. Personas were very useful during this project, as creating the VR office prototypes for some certain people was not inclusive, however creating a persona from scratch and testing it with other people might not have given correct results, therefore basing the persona on a real person but forming it into a more inclusive persona was the method that was used in this project. Scenarios are very useful to realize the full interaction of the user with the design in general. However, in this case, the UI design and the full research is not complete yet, and interaction process from

beginning to end has many missing places that need to be added with the results gotten from other prototypes, tests, and research, therefore using scenarios would not benefit much at this stage. A popular method to help with evaluating the ideas is KJ analysis, which consists of writing down everything that is related to the design; the concerns, actions, possibilities, similar issues, feelings and such to different cards, and gathering them in different groups. This helps with understanding the problem and possible solutions, and finding and evaluating the ideas that are the result of this grouping. The main problem with KJ analysis was that everything related to the project created another problem to solve, like the social aspects and such, and had to be cancelled out since many aspect are not within the delimitation of the project, therefore after cancelling all the groups only one remained, which was the initial goal of creating a toolbox for designing VR offices. This method was started being used, however it was realized that in this case it would not work well therefore was scrapped.

After the research phase was done, brainstorming was used for ideation and sketching was used to create some versions of the possible end design of the tool. With A/B tests different versions of the prototype are shown and tested with the user, seeing which version is more desirable, and which one is more usable. This test was used to a small extent; before the prototype was completed many small sketches were made, and using these sketches some A/B tests were made, asking the users which one might be better. Wireframes represent the structure of the UI and show key elements and is another possible way of creating initial versions of the design. They are useful for explaining the design to other team member, and sometimes clients. During this project I was mostly working alone. When it is needed to explain the UI and the usage to users sketches and prototypes were much better alternatives, as there were no multiple-screen structure in the design and explaining things in detail with sketches and prototypes were more suitable for the situation, therefore wireframes were not necessary in this project. Prototyping was used to further on realize the design, and these prototypes were used in usability testing. Heuristic evaluation is mainly used to identify problems with a UI, and used mostly with digital prototypes. This evaluation was planned on being used with the digital prototype, however unfortunately digital prototype was never made and with a physical prototype that did not include any error messages, file navigation and similar software properties, it is not suitable. User flow visually explains the route the user takes while completing some tasks. It is necessary to realize how the user might start using this product. This will be necessary in the future to figure out how the user will get the VR office -through their own design or through another designer- and many other things that are not yet thought of during this process. However, there is still much more to be researched and more testing-prototyping needs to be done, so it is early for a user flow.

# 4

# Process

The process for this project can be categorized into two main sections; Research and Design. In the Research section, some user research was done with interviews and observation. These were to provide understanding for creating prototypes for VR offices the users will test. These prototypes were done to understand the common and individual parts of the VR offices for different people, which is necessary to create more personalized VR offices. The Design part focuses on the design process of the program that will help users create their own VR offices according to their wishes.

Throughout this process, 8 people were deeply involved with the interviews, prototypes, and various testing. Starting with these 8 people and following the complete design with them was done in order to put the users in the center of the design, and follow up with user feedback after every step. Using the same people from beginning to end made it easier to explain the new steps, as using new people for the tests every time required a thorough explanation from the beginning, including both Research and Design parts, which would not be feasible considering that the users' participation in the virtual office testing was very necessary as it provided a large context for the user, therefore changing users would also provide uncertain or false results. These 8 people were chosen from different backgrounds, occupations, and age, and their accessibility took a big part. Whether they have used VR applications before or not was influential in the choosing process. Below is some basic information about these people.

| Occupation | Gender | Age | Have Used VR |
|---|---|---|---|
| CEO | Male | 58 | Yes |
| Secretary | Female | 44 | No |
| Master Thesis Student | Male | 25 | Yes |
| Master Thesis Student | Male | 25 | No |
| Graphic Designer | Female | 29 | Yes |
| Ophthalmologist | Female | 55 | No |
| Software Engineer | Male | 28 | Yes |
| Software Engineer | Female | 35 | Yes |

**Table 4.1:** 8 involved all through the process

## 4.1 Research: First Round

In the first round of the research phase, majority of the user research is done through observations and interviews. This round was mainly to identify the target audience, investigate the design space, and to realize the possibilities a VR office can bring to an office worker's life with the usage of value proposition and Now Wow How Matrix.

### 4.1.1 Observation

When virtual and augmented reality offices are considered, there is a very large potential user base, which makes it harder to focus on the specific needs. Choosing a target group for this project needed to be unbiased and based on classifications that are found with the result of solid observations. Therefore in order to understand the potential users and find a target group, some naturalistic observations were made. In total, over 15 sessions of observations were done through 9 days, totaling to over 24 hours.

Observations were made in as different environments as possible. In multiple universities, both the students and the teachers were observed in their working environment and in their offices. Many public places with accessible offices, and some private offices that required special permission were included in the observations including R&D department, HR department, secretarial and managerial offices of a private company, some doctor offices, nurses stations, and secretarial stations in a hospital, and a tax office. During the observations, when deemed necessary some questions are asked about the working process and office usage, however these were not detailed enough to be counted as interviews, and the information gotten was only recorded in small notes.

### 4.1.2 Interviewing

Semi-structured interviews were conducted in order to further understand the potential users and find what kinds of virtual offices should be prototyped. In total 21 interviews were done, and they did not always follow predetermined questions; the questions were asked according to the previous answers given. However, the following questions were always asked, or the answers were tried to be found through different question in every interview;

- How much time do you spend in your office?
- What are the regular activities you do in your office (such as writing, signing, coding, filing, sending..)?
- How essential are social interactions in your regular day of work?
- What do you do in order to relax during your working hours (listening to music, looking at cat photos etc.)?
- What kind of environments are suitable for working for you?
- What do you do to keep yourself motivated during work?

The following is the basic information of the 21 people that were interviewed.

| Occupation | Gender | Age |
|---|---|---|
| CEO | Male | 58 |
| Director | Male | 60 |
| Vice president | Male | 49 |
| Research Associate | Female | 50 |
| Research Scientist | Male | 52 |
| Secretary | Female | 44 |
| Secretary | Female | 35 |
| Secretary | Female | 40 |
| Master Thesis Student | Male | 25 |
| Master Thesis Student | Male | 25 |
| Student | Female | - |
| Student | Male | 38 |
| University Instructor | Female | 55 |
| Veterinarian | Female | 25 |
| Graphic Designer | Female | 29 |
| Lawyer | Female | 28 |
| Ophthalmologist | Female | 55 |
| Psychiatrist | Male | - |
| Software Engineer | Male | 28 |
| Software Engineer | Female | 35 |
| Software Engineer | Female | 29 |

**Table 4.2:** Interviewees

### 4.1.3 Now Wow How Matrix

After the user research with observations and interviews, a now wow how matrix is created to find the possible implementations of VR offices, and what they might include and improve while working in the office. This is done by replacing 'impossible to implement' axis with 'in research/will be available soon' axis since many of the ideas were not possible in this project, but the technology that will make the idea possible was still being researched and developed in other projects. The categorization of the ideas is mainly done to determine the delimitations of the project.

## 4.2 Research: Second Round

In the second round of the research phase, four people are chosen for shadowing. These four people are interviewed later, and some personas were created with the result of the shadowing and the interviews, along with the observation and the interview sessions made in the previous rounds. Further on, three prototypes were created following these personas. These prototypes are then used in usability testing.

### 4.2.1 Shadowing

Initially, four people were chosen based on difference in occupation, comfort they have in giving in depth information, ability to let someone else observe and shadow during a work day, and the comfort they feel while being shadowed. The latter two conditions were very hard to fulfill, as many people acted differently while there is an observer, or the existence of the observer sometimes hindered the person and the observer had to leave. These four people were followed five hours of a work day each; three physically shadowed, one was followed live through a body cam.

During shadowing, various aspects related to people's office usage were observed, such as: occupation, time spent in the office, time spent by activity, personal mood and feelings in the office, social actions performed in office, time spent not actively working (for example thinking, searching, small breaks, actions that are related to work), personal preferences about their offices, some habits that affect their way of using their offices etc.

### 4.2.2 Office Worker Types

During observations, numerous people's working styles, actions they perform, their environmental preferences while working and many other working and office aspects were noted. With the answers of the interview questions and what was gathered through the observations, certain similarities were observed amongst some occupations that spend most of their time in their offices. These similarities led to a categorization of the occupations under certain types with respect to the characteristics they exhibit, such as the amount of social interactions necessary, the nature of the social interactions necessary (meetings, phone calls, customers..), necessary physical movement, amount of documents handled, type of documents handled, time spent doing tasks, and so on. The main questions asked while categorizing were the following ones.

- How much social interaction do people have while working?
- What are the aspects of the environment different people value?
- What are the users expectations from a virtual office?
- How dependent people are to physical objects, such as pens and papers? How many of them can actually be virtualized?
- What are the regular actions people do while working?
- How much time is spent actively working (writing, reading, etc.) vs. how much time spent passively working (thinking, socializing with coworkers etc.)?
- What are the constraints of their physical offices?

This categorization helped with putting some limitations on the research and testing.

### 4.2.3 Interviewing

After shadowing the chosen four people, another interview session was done. These interviews were not structured, and were mainly done to ask questions accumulated through the five hour shadowing, and further on understand the details about their office usage.

During these interviews, the users' offices were sketched roughly. What would they want to have in the virtual office created for them; what is important and necessary, what is desired was discussed. A virtual office is then created following these wishes for the users to test the desired virtual office of the persona that is based on the person who described it. The following are the properties of the offices these users work in, and some properties of the desired virtual offices.

#### 4.2.3.1 First Office

Original Office

- One short but wide cupboard
- One tall and narrow cupboard
- A very large office desk
- A laptop on the desk
- Some files that need to be signed and approved are usually there
- A comfortable office chair behind the desk
- Two armchairs in front of the desk
- A small coffee table in-between
- Nothing on the walls or surfaces

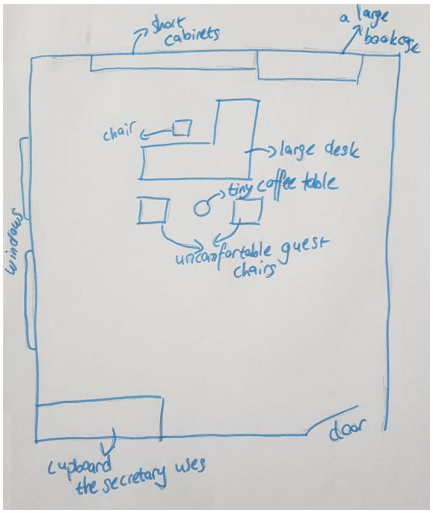



**Figure 4.1:** Sketch of the first office layout.

Desired Virtual Office

- A sea scenery
- Looking at the sea from a high place, not sea shore
- Some plants and greenery around
- Not too sunny environment
- The desk alongside the things on top are visible

#### 4.2.3.2 Second Office

Original office

- A very large, high ceiling room
- 8-10 desks and chairs
- An entertainment and relaxing place
- Some various sized cupboards on the sides, but not too many to make the office feel stuffy.
- Light colors. No brown furniture and such, makes it feel confined. A bit of colorful accents

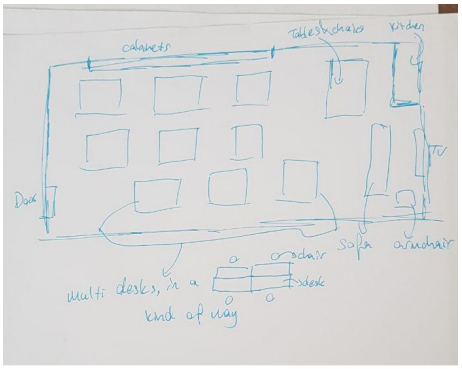



**Figure 4.2:** Sketch of the Second office layout.

Desired Virtual office

- Own desk and laptop are visible
- Each coworker's working space that includes the chair, the desk, and some movement space, are represented with transparent glossy boxes in order not to cause collision
- A huge whiteboard to organize thoughts when the user sees everything that is related in front of them.
- A large empty room. Seeing ideas, thoughts, concepts related to the project around them might be good for the user.
- Empty place is important to reduce distraction

#### 4.2.3.3 Third Office

Original office

- Very small room
- A desk with PC
- A cheap chair
- Window right behind of desk
- Single bed right next to the desk
- A tall but narrow cupboard

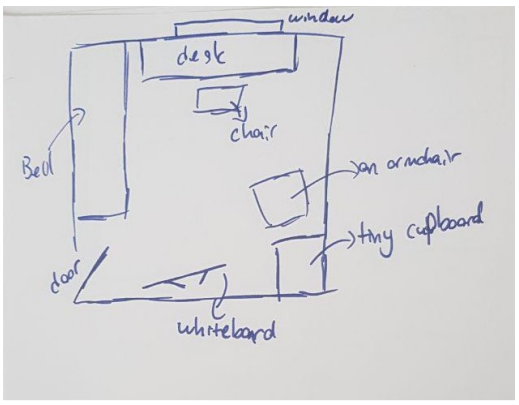



**Figure 4.3:** Sketch of the Third office layout.

Desired Virtual office

- A big open area
- A mountain overlooking another mountain/valley
- The desk and bed are present on top of one mountain
- The limitations of the room should be obvious. All the objects and the walls are represented with transparent glossy boxes

### 4.2.4 Personas

Combination of the interviews and the shadowing, four personas were created based on these chosen four people. These personas are created as in depth as possible, following the real-life user they are based on only to a certain point, since the personal choices, wishes, quirks, and preferences affect their personal virtual offices to a great extent, directly determining the control the user has, or feels they have. This is done in order to provide a very personalized prototype for the user. Out of these four users, three of them were suitable for basis of the user test prototypes we needed. One person, who is a secretary, had too much movement involved with her work and social interactions with many people to make VR office prototypes feasible.

#### 4.2.4.1 Jay - Filer

*Jay is 55 years old. He has been working for the same company since he was 22 years old, and it has paid off. He has risen to become the CEO, a position he has worked for so much, and has maintained his position for the past 9 years. Jay is originally an agricultural engineer, with a degree in milk and dairy products, and with the combination of him being a very friendly and genuine person with great people management led him to be a great asset to the dairy product company he is working at.*
*Jay has a very specific kind of office. He does not like clutter at all, and since his spouse is a bit of a hoarder their house has lots of things all around, therefore Jay's office is a bit of a haven for him. There is nothing that could cause a clutter; seven pieces of furniture in his large office, and no decoration but the model vintage car his spouse got for him. Apart from his laptop, pens, and some little paper, nothing can be found on his desk. The office feels very fresh and relaxing; it also feels like Jay could run away at any second and no one will ever know he was there. He also gets lots of visitors all the time, mainly different managers. He must talk with the managers a lot the whole day, and in-between discussions he has to evaluate many things about the company to make impactful decisions. Even though Jay is a friendly person, he appreciates solitude and finds it much easier working alone, which is something he does not get often. In his old office, he had a very comfortable sofa, and two armchairs that made you sink in and want to sit day the whole day, resulting with*

*the visitors staying for much longer than necessary. Remembering that, Jay got two very uncomfortable armchairs for this office, and no sofa, and now people want to leave as soon as they are done, leaving him to do his work comfortably.*
*The preferences Jay has about his office, however, create some problems for his secretary. Since Jay does not want many things in his office, she has to keep the necessary files for him, which made her working place a lot more crowded than it is supposed to be. She also has to arrange all the visitors very carefully; if many people come one after another Jay will start complaining. Also, many of the managers and Jay have been working in the same place together for years now, and they are good friends, which sometimes results with people coming in unannounced. The secretary has to take care of these too, and more often than not she has to lie about him being busy or in a meeting in order not to let anyone in while Jay prefers to be alone.*

#### 4.2.4.2 Jordan - Creator

*As a 28-year-old, Jordan's family thinks he has accomplished a lot in his life. He has a major in systems engineering, a minor in electronical engineering, and a master's degree in industrial engineering with many publications and researches he has participated in. He has started working as a consultant in some startups even before he finished his master's and started working in large companies as soon as he has gotten his degree. For the past few years he has a very comfortable job in one of the biggest companies in the world, and earning more than his parents combined, which he thinks made him and his partner spoiled. Jordan is very smart, yes, but the reason he achieved so much is mostly because of his personality. He is a very charming person; he is friendly, intellectual, humble, caring, and makes a person feel like they are his closest friend in 15 minutes. It is very hard not to like him. This is actually a great asset for him in his working environment. He works at an open office with many people in the same large room, which enables lots of communication between them. They are mostly working on the same project, and the communication between the researchers, programmers, and designers is much easier and well established in such a place. The room has around 10 people's desks in it, however it also includes some resting and entertainment areas that has TV's, sofas, and some game consoles too. It is designed very nicely and it feels open, calm, and relaxing, however Jordan feels a bit off since he cannot choose anything about the office he works in apart from what his desk contains. This makes him feel somewhat confined to other people's decisions and preferences.*
*Many people working in the same room over the same project makes it so that everyone talks with each other almost all the time. Jordan enjoys this; he can get help or help other people very easily, and it is much easier progressing through a project while brainstorming all the time with the others, and it feels like everyone is pushing each other to do more and do better, which results in a very productive and good working environment. However, he sometimes has some interesting ideas he wants to improve on, or gets stuck on something, so he wants to think a lot. That is actually one of the things he does at home too, he just lays on his bed, closes his eyes, and just thinks. Many of the solutions to his problems, and many great improvements to his projects have been found like this. It is quite hard to do such a*

*thing in this office though, Jordan usually leaves and goes home early to just think calmly without anyone interfering.*

#### 4.2.4.3 Taylor - Researcher/Creator

*Taylor has been quite an absentminded person for all her 24 years of life. She has always been a quite person that is not interested in anyone else. She only cares about her work, the really close limited number of people in her life, and playing video games. Taylor is currently working on her thesis. It is not going quite well, the thesis supervisor is really uninterested in her work. The supervisor was planning on taking in a thesis student while he is working with other companies and researches on the subject, but it got cancelled after Taylor started working on the thesis, and she got left with a thesis supervisor that knows very little about the work. The worst is the supervisor keeps constantly changing his mind about what he wants. He initially said there is no need to test all of the things Taylor researched about because it takes way too much time and it is hard to code, and next month he scolds Taylor for not doing the testing. This is putting a lot of stress on her. Taylor also does not have a good working place; she has an office that she shares with a small research group, which is comfortable, but she does not have a computer to work on, and her laptop is not strong enough to run all the calculations she is doing, therefore she prefers to work at home.*
*Working at home is another issue. Taylor is currently living with her partner in a small apartment. They have decided that it is best if they set the apartment as living room, bedroom, and study room, and they also decided that it would be Taylor's study room, as she is very particular about her things. It is a very small room, barely enough space to turn around, which make Taylor feel claustrophobic. She has a huge window right in front of her desk, behind the PC monitor, which helps her with this feeling a lot, and the small plants her partner put in front of the window make her feel more relaxed. She sometimes gets this urge to nap in the middle of working, even for 15 minutes, therefore she has a small bed right next to her desk, which is useful when she needs thinking too.*

### 4.2.5 Prototypes

The initial virtual office prototypes were created in order to understand:

- How different users act and react in the virtual environment?
- What are the aspects of the environment different people value?
- What are the users' expectations from a virtual office?
- What parts of 'virtuality' are useful?
- What are the intuitive actions users perform?
- What makes the user feel in control?

By finding answers to these questions, important parts of a virtual office were aimed to be understood. It is found that there are varied priorities for different types of users; some users value the fantasized environment VR gives while some users value

the convenience a computer gives which can be used in a VR environment.

For every person, two different offices were created in Unreal Engine, using Gear VR as it is a very accessible device that does not require the presence of a computer during testing. One is to represent the original office they have, which will be used during testing with users different than the person the office is based on in order to provide more understanding of the persona and their work environment. The other one is the 'virtual' version of the office, which represents how the person would want their VR office to be like.

During the shadowing, the personal offices are observed in-depth, and all the furniture, objects, and everything are noted in order to create the 'real' office as close to the original one as possible. The 'virtual' version of the office is created using the observations gathered from the shadowing, and the answers the person gave during the interview.

The following three pairs of real and virtual offices were created for the initial user testing. The users were asked to get to know the real office and familiarize themselves in a way that they will think it is their own offices. After the real office prototype, the users were asked to use the virtual office.

**First Office**

**Figure 4.4:** Implementation of the real office sketched in Figure 4.1 in Unreal Engine.

**Figure 4.5:** Virtual Reality version of the first office. The office is set on top of a hill overlooking the ocean as the user's preference.

### Second Office

**Figure 4.6:** Implementation of the real office sketched in Figure 4.2 in Unreal Engine.

**Figure 4.7:** Virtual Reality version of the second office. The office is completely empty as the user desired that way.

### Third Office

**Figure 4.8:** Implementation of the real office sketched in Figure 4.3 in Unreal Engine.

### Third Office

**Figure 4.9:** Virtual Reality version of the second office. The office is set in nature, overlooking some mountains and a river.

### 4.2.6 Usability Testing

For the three different real-virtual office pairs three groups were made consisting of three people each, overlapping in some cases, having eight people in the tests in total. Every VR office was tested by the person they were based on, and two other people that have similar working environments or office habits. Tests were made using a Samsung S8 along with a GearVR with controller. The usage of GearVR enabled easy testing without spending much time, therefore different people from different places were able to participate in user tests. Two of the tests were done through live video chat, with the users having to use their own device, which was again a Samsung S8.

## 4.3 Research: Third Round

After the usability testing, another round of interviews were done with the users. With the feedback from these interviews some small additions were made to the prototypes, and the rough testing of the gestures were made.

### 4.3.1 Interviewing

The initial usability tests were made in different times and places, therefore after gathering all the results from them, another interview with both the test participants

and other people needed to be done in order to understand the needs and wishes of the users better. For this, semi-structured interviews were conducted to find out what are the necessary aspects of the virtual offices, what might make them feel in control, and what are the different desires of different people so that they feel the offices are personalized.

### 4.3.2 Usability Testing

The second round of user tests were mostly focused on the gesture usage and the comfort the users have. The goal was to find out the gestures users have in general, and the ones that individual people have differently. For example, to get rid of a visible item some people prefer flicking while others prefer crumbling and throwing away. Implementing gestures was not within the delimitations therefore these tests were not done with the feedback from the prototype. The user was verbally asked to do some certain actions and manipulate some objects. The gestures user preferred to use are observed and noted. This testing is done to see the similarities of the gestures different users prefer to use, in order to categorize these gestures to further on use in the office creation tool.

#### First Office

This prototype mostly is the same as the initial prototype, the only difference is the user can actually change between the 'real' and 'virtual' offices. This was done with the user disabling the virtual office on the controller, and the real office could be seen in the headset. By pressing the same button on the controller, the user could re-enable the virtual office. In practice, the 'real' office would be the original office in the physical world, enabling the user to see and use their original office without taking the headset off. This makes it easy for the user to change between virtual and real offices fast, as there might be many people coming and going form the office.

#### Second Office

The main difference from the first prototype was the feedback of the various objects and people within the room. The indication of presence of something got changed from transparent glass effects to particle effects that are shown with proximity.

The users were also given a set of tasks to perform to see the intuitiveness of the office. These tasks were conversing with a coworker whose desk is next to the user and use the whiteboard. Although not implemented in the current prototypes, the users were also asked to manipulate virtual 3D objects that will aid them with their creative process, memory, and understanding of the current work they are doing. This was asked in order to find more about the natural hand gestures people expect to use in virtual environment, and to find out what kind of access people expect having to such objects, such as taking them out of thin air or looking inside a cabinet or such.

#### Third Office

A difference from the first prototype was the feedback of the various objects and the limits of the room. The indication that there is something got changed to particle effects that change with proximity, from transparent glass effects.

## 4.4 Design: First Round

In order to create an UI for the VR office design tool, firstly brainstorming is done. With the possible ideas of the brainstorming some sketches are created. These sketches are then used in usability and A/B testing to find the more desirable and usable ones.

### 4.4.1 Brainstorming

In order to come up with some interface and interaction ideas, a brainstorming session was held solitary. The previous findings about what the users value in virtual offices, what makes them feel in control, and what makes them feel comfortable were focused on. Also, the fact that the users are not expected to know interior design or any similar subject was a big factor to consider.

### 4.4.2 Sketching

After analyzing the ideas that are the results of the brainstorming session, some of them were made into sketches. Initially, sketches were just small parts of the whole design, to determine which parts of it are useful to the user.

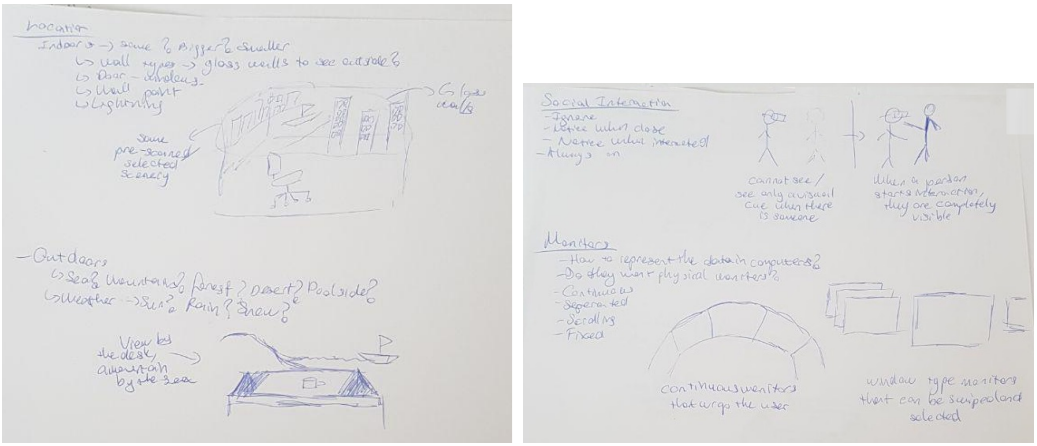



**Figure 4.10:** Early sketches done to find the possible configurations of the VR offices that can be used with the tool.

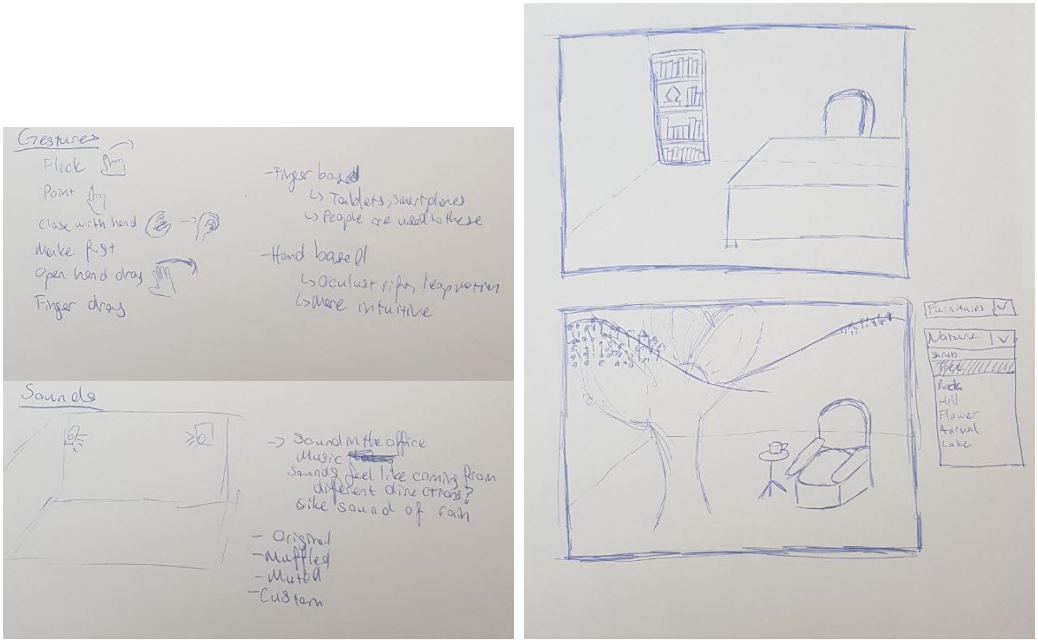



**Figure 4.11:** Early sketches done to find the possible configurations of the VR offices that can be used with the tool.

### 4.4.3 Testing

Many different versions of the partial UI is shown to the users. These partials were tested as the users were asked to navigate through the parts. And then the users were asked to choose the one they find more appealing to them.

## 4.5 Design: Second Round

The existing sketches are improved and new sketches are made with the feedback from the users. These sketches are used in creating the paper prototype. Usability tests were done in this phase using the paper prototype.

### 4.5.1 Sketching

With the feedback from the users after showing them the initial sketches, further improvement on the design is done with new sketches. This time, major parts of the application are designed with many different options. These sketches were more in depth than the previous ones.

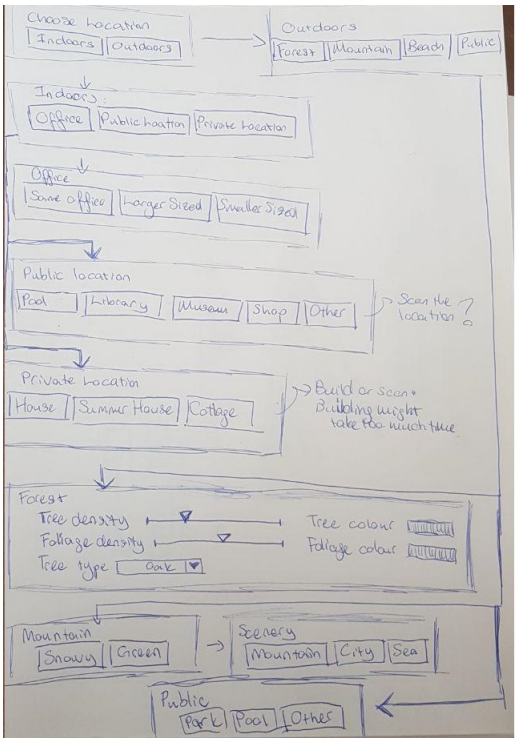



**Figure 4.12:** Possible flow of selecting the options at the beginning of the application.

### 4.5.2 Paper Prototype

Taking the sketches and the feedback from users as basis, a paper prototype was created. This was partially interactive prototype, and was made to understand whether the user finds this design intuitive and useful.

In this prototype, lots of freedom in usage of the interface is given to the user. In order to provide this, the number of selections in each of the settings are limited to a very small number, for example, the locations that the user can choose are indoor office, lake and mountain, snowy mountain, and beach. In the prototype, initially a setup needs to be completed to show the base office with the desired settings.

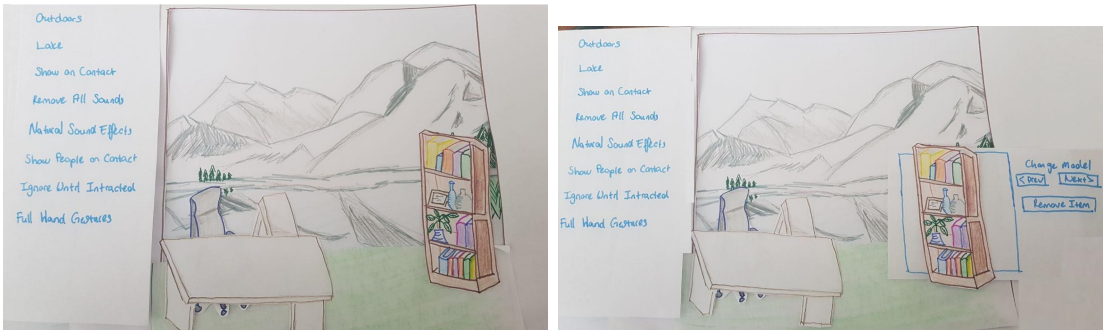



**Figure 4.13:** The quick options for items in office. Removing the bookcase(1).

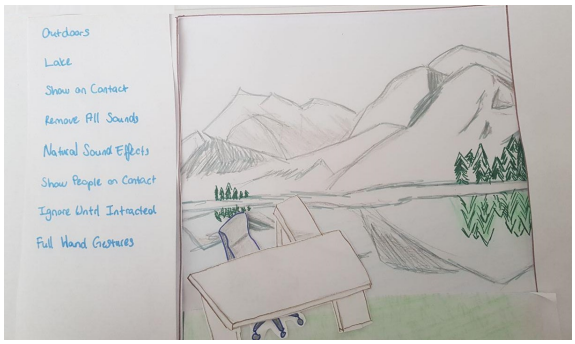
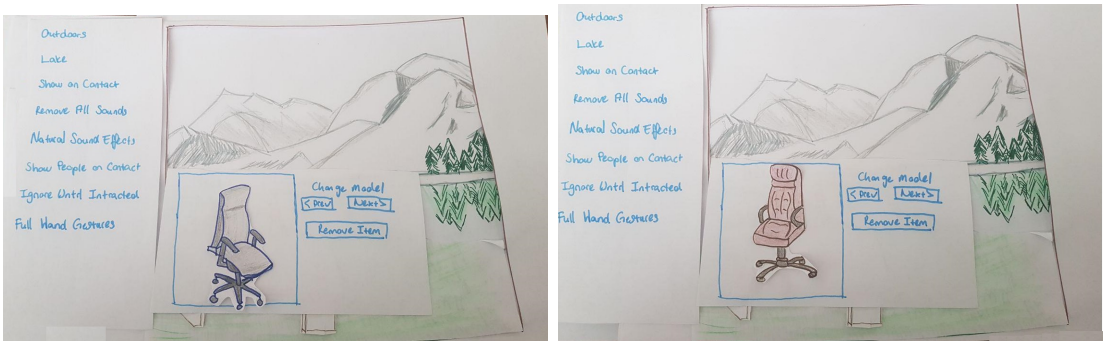



**Figure 4.14:** The quick options for items in office. Removing the bookcase(2).

After the setup is done, the user can move, change, or remove the objects in the office. The users can also change the settings that are decided on the initial setup, such as the location of the office.



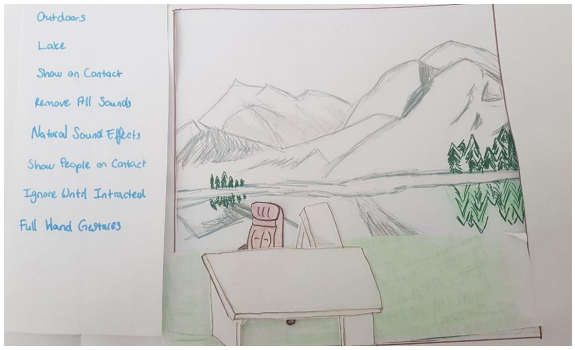




**Figure 4.15:** The quick options for items in office. Changing the visuals of a chair.


**Figure 4.16:** Changing the location of the office after the setup.

### 4.5.3 Usability Tests

The design was tested using the paper prototype. The users were asked to do certain tasks in order to see the usability of the design. The users are initially asked to complete the setup of the application. In this setup, the users are asked to choose

the location that they want their office to be in, how they want the limitations of their office to be shown, which kind of gestures they want to use, what kind of sound they want in the office, and how to handle social interactions. After this setup is done, an office that is at the chosen location is presented to the user.

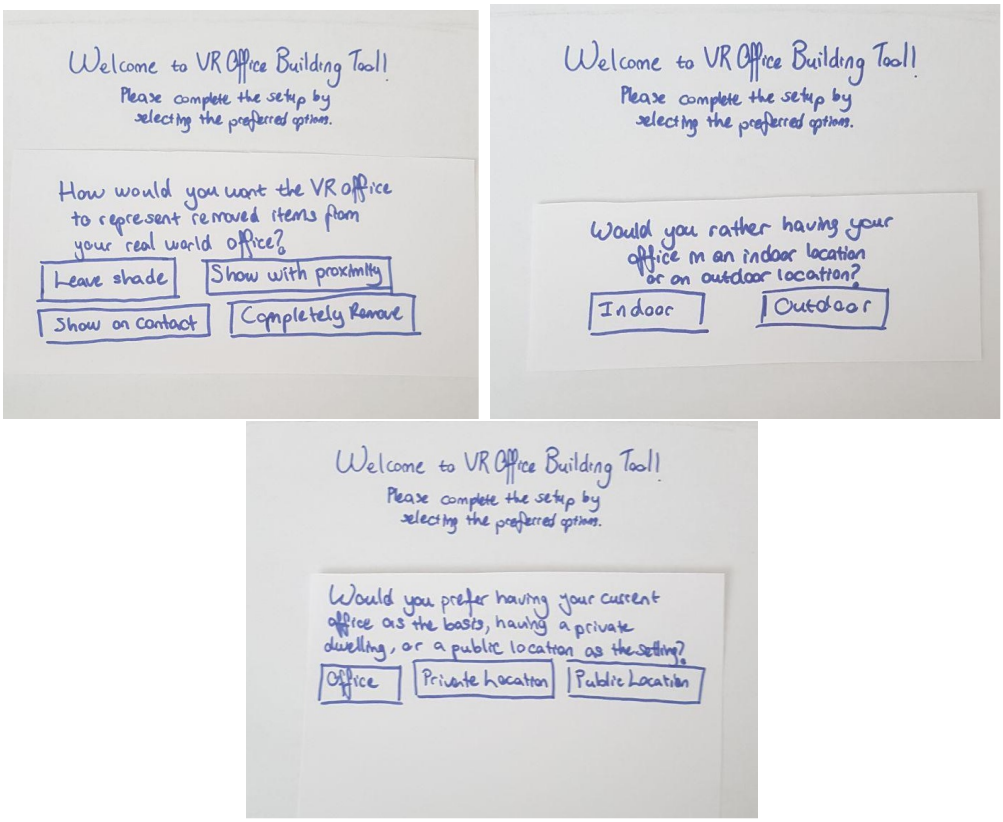



**Figure 4.17:** Some part of the setup process where the user should select some options to configure the VR office.

After the setup of the office various tasks could be done by the user according to their wishes, such as changing the desired location the VR office is in, removing items from the office, changing the looks of items in the office, changing the type of foliage around the office, and increasing/decreasing the density of the foliage around the office.

### 4.5.4 Feedback From Users

After the paper prototype sessions, the users reactions and thoughts are noted. Their usage of the prototype directly shows the effectiveness of the design as this is the last prototype and a final design could not be made during this thesis, therefore the feedback is very important in this stage. These notes form the feedback and is the main result of usability testing of the paper prototype, which will be detailed in Results.

# 5
# Results

## 5.1 User Research

### 5.1.1 Office Worker Types

For Office Worker Types, initially more than 12 types is categorized, but it was later realized that most of them could be combined into one single type as the differences were very little and mostly included one single occupation, and going into such in depth detail about some occupations while leaving the other ones barely researched would not have unbiased results. Eventually, four types were categorized to help the research. Some occupations, such as clerks and R&D, have properties of two types. One very interesting finding, which needs more research to be done to validate, was that people of the same type displayed similar personal characteristics, such as Organizers are usually extroverted and Researchers prefer working solitary.

**Filer**
These types of users usually manage physical files. They have to sort, receive, send, sign, etc. paper files or packages such that the majority cannot be managed in virtual environment. They usually have a lot of interaction with others, often shorter than a few minutes. They use their devices (computer, smartphone etc.) to send mails, memos, make calls very often. They usually have meetings with other coworkers daily, and sometimes multiple times a day. These types include jobs such as directors, department heads, managers, HR, clerks, and officials.

**Organizer**
These users have to deal with many files at the same time. The files are not necessary physical, but they may require many physical to digital translations. These people categorize and sort files and various form of information, send them to their necessary places, collect from different places, as well as manage time, appointments, meetings and such. Secretaries, clerks, event planners etc. fit this type.

**Researcher**
These users gather specific information from various places. They have to search and find information mostly from outside (of the company) sources, categorize them in a way that they will be useful to the specific topic they are working on, make sense of them and present the findings in depth. Research and development, PhD students, etc. belong to this type.

**Creator**
These users do not use office tools all the time. They have to come up with a base to work on such as an idea, an algorithm, or a design, and improve on this base using the tools they have, to create end results. They usually work in projects, and they spend a lot of time alone trying to form and improve their projects. Their work processes are usually not stable, which might result with hours spent just thinking and searching for a solution to a problem, working non-stop for hours without break, or talking to find more aspects of the project with their coworkers or some clients. These types include designers, developers, programmers, architects, engineers, etc.

### 5.1.2 Delimitations

Using the findings from the user research, some delimitations were put on the project. First of all, implementation and testing of social interactions within the VR office prototypes will not be done. This includes all kinds of social interactions and possible collaborative workspaces, such as the user interacting with another VR office user, the user interacting with someone without a headset, and so on. These may be discussed in the interviews to see the general preferences.

The gestures will not be implemented, but small tests to see preferences will be done.

Integration of the real world objects will not be implemented as the technology for this is still being developed and refined for real time cases. Real world objects will be represented with similar virtual objects. A visualization for distinguishing the representation of integrated real world object and a regular virtual object might be implemented.

Implementation and testing of personalized notifications, such as incoming calls and e-mails, will not be done. This is a big part of the personalized VR office design, however more than testing what kind of notification people prefer, testing of different notification and the relaying of this information while following the calm technology principles should be done first, however this is a topic for whole another research.

Lastly, necessary usage of keyboards and possible ways of replacing the keyboard input is considered, however in many cases, such as writing codes, no solution apart form enabling the user to see both their hands and the keyboard in VR office came to mind. Therefore different inputs and possible implementations of those apart from gestures is not considered in this project.

## 5.2 Usability Testing for VR Office Prototypes

### 5.2.1 First Tests

The first usability test results depend mostly on the feedback given by the users. The following tables consist of the quotes by the users indicated.

#### 5.2.1.1 First Office - Jay's

<table>
<tr><th></th><th>First user</th><th>Second user</th><th>Third user</th></tr>
<tr><td rowspan="2">Social</td><td>Great way to ignore people easily</td><td rowspan="2">Person would feel completely alone, but probably in a nice way. Can go back to society whenever wanted.</td><td rowspan="2">Feels too lonely, I would want some people around me.</td></tr>
<tr><td>Holographic version of me in the meeting without the headset on it would be perfect</td></tr>
<tr><td rowspan="2">Feeling</td><td rowspan="2">The scenery and the mood the environment gives is very relaxing</td><td rowspan="2">Existence of a desk in that scenery is off-putting</td><td>Too big of a place. Makes me feel cold and unsafe.</td></tr>
<tr><td>It is very relaxing, but I don't think it is suitable for an office.</td></tr>
<tr><td>Feeling</td><td>It is great for the stress my work causes</td><td>Scenery is overall nice.</td><td>View is good, but it would distract me from working. Would feel like I'm on a vacation.</td></tr>
<tr><td rowspan="3">Purposed additions</td><td>Seeing my graphs in 3D in front of me and manipulating them might be almost necessary</td><td>Desk is necessary as the person this office is for is using his desk all the time for signing things and so, some other representation?</td><td rowspan="3">Some reminder that this still is an office might be necessary.</td></tr>
<tr><td>Manipulating things like the sound or the intensity of the sun would be great addition</td><td rowspan="2">Seeing own hands while signing things and so would be necessary</td></tr>
<tr><td>I'd like if the VR office recognized who it is and depending on the person it would show or not show the person</td></tr>
</table>

**Table 5.1:** Quotes from the first office test.

First usability testing was done with the person Jay was based on. He wanted the office to recognize who it is within the original office, the person might not be shown if it was decided so before. For example sometimes the secretary needs to come in

to take something, or someone brings in a tea, and he would not want to see those people not to distract himself, and some people he just does not want to see. It is not within the scope of this project but it might possible if a camera with a very good facial recognition program is installed on the door, therefore in the future this might be implemented.

He would also benefit a lot from a virtual collaborative workspace, however this is not within the delimitations of the project. Although, if such virtual offices are used by everyone it might be possible to have a virtual meeting. One big problem is that if the visitors are not his friends or people who know him well, it is not good to have the headset on, it would be rude and he might need to take it off often.

#### 5.2.1.2 Second Office - Jordan's

| | **First user** | **Second user** | **Third user** |
|---|---|---|---|
| **Social** | Good I cannot hear other people. | Without the people around the office does not feel like an office. I do not like that I am alone here. | I do not mind not having people around. They are usually bothersome anyway, but lack of people makes this place seem too big. |
| | Feedback as to where the people are passing from is kind of necessary. I would close my eyes to think even with the headset on, and might do it in the middle of the room. | | |
| **Feeling** | Feels really empty and needs some very mild decorations. Maybe some paintings. | Very big and empty and way too bland. | The large empty room is very nice |
| | | | Makes it feel more 'free', like the whole office is made for me. |
| | | I'd want more things visible to make me feel comfortable. | The desk is at a spot that is not middle of the room but towards a corner makes it look a bit weird |
| **Purposed additions** | Some indication that the large sofa is free that I can see from afar can be great. | Putting some fake furniture, opening up the roof to see the sky, or just separating the working space from resting place might make things homier. | Limiting the visible space in the office even though there is more available space might be a solution to awkwardness of the position of the desk. |

| | First user | Second user | Third user |
|---|---|---|---|
| **Purposed additions** | And a notification that if all the seats in the resting area are taken, so that I won't go all the way there. | Maybe we can still see the people? I'll admit they are usually too loud, but if I don't see anyone it doesn't feel like an office. | Since it is a room, make it feel like the music is coming from some speakers on the walls, like we should hear from different directions and such. |

**Table 5.2:** Quotes from the second office test.

#### 5.2.1.3 Third Office - Taylor's

| | First user | Second user | Third user |
|---|---|---|---|
| **Social** | No social aspects were discussed in these tests. | | |
| **Feeling** | Very comfortable. Feels much bigger and I can actually breathe. | I love the feeling of being in the mountains. | No matter how nice the mountains look, knowing that they are virtual makes me feel like I am trying to deceive myself. |
| | I like the fact that the scenery is there but the cold and the wind is not. Feels better and doesn't make me feel way too relaxed in the breeze. | | Since the environment is virtual it does not give the relaxing feeling a real mountain environment would. |
| | | I kinda feel cold just seeing the scenery. | Trying to catch some fault with the foliage, or just looking at the details will make me very distracted. |
| | I feel like climbing the mountain in front of me. | | The virtual feeling of the environment might be a good feeling as it will not allow the user to feel like they are actually on a vacation |
| **Purposed additions** | Being able to change the weather inside the office would be amazing. | | |

| | First user | Second user | Third user |
|---|---|---|---|
| **Purposed additions** | During the weather changes some furniture changes might be necessary too, for example having some roof or a gazeebo when it is raining. Even if I cannot feel the water it would be more comfortable and I won't subconsciously think of getting wet while working. | When a piece of code finishes running, the comparison of the algorithms or simulations should be immediately visible. When the computation is done, some notification can be sent to the user, and they can see the result and compare it with the previous result easily. | |
| | To overcome the urge to climb some obstacle is necessary, for example, a valley in between here and the mountain. | A whiteboard that is easy to manipulate should be there in order to keep is formulas in front of his eyes at all times. | |
| | Having the different 'monitors' up at all times and having easy switch between them would be very nice. | | |

**Table 5.3:** Quotes from the third office test.

The first user was very reluctant to moving around. He knew this is supposed to be his office, which has around $1,5m^2$ of moving space, and since he could not see the walls all the time it made him feel reluctant about moving around. During this test the integration of the computer usage is talked about a lot. This user does many simulations, and he needs to switch between the results and the codes all the time, and when the simulations are running he has spare time during which he either rests, or does some other work. Even though he does not have them, using multiple monitors is very convenient for him. However at the same time he does not want the screens to cover the majority of his vision all the time, he is at the top of that mountain with that scenery for a reason and he wants to view it sometimes.

### 5.2.2 Second Tests

The tests in the second iteration were mostly focused on gestures and control of the office. Every person had different way of using the gestures; the older people (ages 55 and 58) and one of the younger people (age 27) who is a graphic designer, preferred using finger based gestures as they are using a tablet, while other people (ages between 25 to 30) preferred using hand based gestures, as if they are using real life 3D objects. This difference in gestures might be because of personal preference, commonly used devices, or age, however the sample size is too small to make any

kind of informed judgment as to what it is.

#### 5.2.2.1 First Office - Jay's

In the testing of this office not much about the gestures was found apart from the personal differences. The addition was the user could change between the 'real' and the 'virtual' office at any time. This change was implemented to see how convenient it is for the user to change between the real world and the virtual world quickly. The users liked the idea at first, but after testing it first user said "I get disoriented as to where things are around the office", and the second user mentioned "The mood of the virtual office completely disappears when I need to go back and forth between offices a lot". In this office many physical items are used, therefore some integration of the real world is necessary to test this kind of office properly.

Another problem with this office was that the first user always tried to open the door remotely with gestures whenever it was knocked on rather than telling people to come in, which represents some problem with the understanding of real and virtual objects and how the user can manipulate them.

#### 5.2.2.2 Second Office - Jordan's

When the users were asked to use the whiteboard in the VR office, only one user attempted to use their finger to write on the board, which is an intuitive approach for writing on a digital surface, however finger tracking was not a part of this prototype therefore it did not work, and after that they could still easily use the controller to write on the board. The other two users' instincts were to put down the controller and search for a board marker, which was not present in the VR office. After internally contemplating for a while and going through the finger-writing phase, the other users were able to use controllers too. This showed that for writing purposes, controllers are not intuitive at all, people are used to either using pens or their fingers, and introducing another way of writing would not be a good solution.

When the users were asked to converse with a coworker (who is represented by particles that are in the shape of a human), all of them initially tried to poke the person. The second user said "I cannot hear what is going on in the office because I am listening to music, and I probably assume the other person cannot hear me too. If the other person were wearing headphones it would be normal to poke them but in this case when I know they can hear me it is somewhat weird to poke them".

#### 5.2.2.3 Third Office - Taylor's

The only difference of this office from the first version was the indications of the limitations of the room, which was well-received by the first user, however the second user said "I don't like it since it broke the feeling of really being up in the

mountains". This showed that different people desire different feelings of reality; some users want to feel like they are actually there while some users might want the feeling of the virtualness in order not to get distracted by the feeling of vacation.

## 5.3 Usability Testing for Paper Prototype

The process of creating the environment was found to be quite easy. One of the users said "If the functioning of the program will be exactly like this, I might even just do the setup and leave everything there", and similar feedback was gotten from four more users. However this might be caused by adding, moving, removing, and changing the objects being too bothersome for some people rather than the design being very user friendly at the beginning and dealing with everything right at the setup. During the tests everyone was pleased with how they can position, add, and manipulate the objects, however some of them had questions about how the interaction would be, for example one user said "Rotating the objects is very easy with hand but might not be so with mouse, how will manipulation of the object be on the computer?". The users that has used any kind of 3D modelling application or game development tool did not have these questions. One user that is familiar with Maya, Autocad and Unity said "It is a very good solution to integrate this kind of manipulation of the environment as using already created assets that were specialized for this task is very easy in applications like Unity, and it looks scarier than it actually is". On the other hand, the users that have never used such an application mentioned that manipulation of the environment might be too complicated for them. Usability testing with a digital prototype is definitely necessary in order to see more about the users' interaction while they are manipulating the world.

Changing the settings of an object that is already in the scene was well received. One user mentioned "Quick access to some functions with a right click on the object is a good for people like me (people that are not used to types of applications that 3D manipulation of objects are made in). Does not force me to jump into the mess of small decisions about objects that I do not understand". In three of the usability tests, the users finished personalizing their offices only after completing the setup and using the quick settings option to remove the bookcase and the lamp. A user also has mentioned "I wouldn't do this by myself if the setup process was not there, and the interaction with the detailed settings part was necessary to do the simple actions such as removing the objects".

When changing the preferences made at the beginning during setup was being discussed, some of the users found that being able to change everything is a bit redundant and confusing for the users. A user said "Some very large parts of the preferences should not be changed easily, like the main location of the office - indoors or outdoors - or gestures - as they are habits rather than preferences". However, providing the freedom of changing their opinion about an aspect of the virtual reality office that they might use for a very long time is important, and if an undesired option is selected during the setup, or some property of the offices is not well re-

ceived, going back to the setup process and starting everything all over again will cause nothing but frustration to the user. However, some future tests with limiting the options might be done.

Overall, the usability tests with the paper prototype showed that the design is progressing well and does not have very impacting usability flaws. However, further testing with improved prototypes should be made in order to reach a final design.

## 5.4 Findings

The following was the question asked for this project:

- *What aspects of a VR office environment are important in making people feel like the environment is personalized and made just for themselves?*

This question was mainly answered during the Research phase. During the interviews and the usability tests with the virtual office prototypes, the feeling of the office being personalized and belonging to the user was focused on. The interviews were done with 19 people in total and the virtual office prototypes were tested with 8 people while only 3 of them had their own personalized office. The number of people overall interviewed and tested was small, therefore an interview on a larger scale should be done in order to get a more reliable finding.

The first and most important aspect in personalization in VR offices is the **physical environment**. This was very expected as the control of the office environment has very big impact on feeling of satisfaction, productivity, and overall mood in the office[6]. When we are talking about the environment in an office, there are multiple aspects to consider. First is the environment within the office; the furniture, decoration, color scheme and such, which is the **office interiors**. This is very important in indoors VR offices. It is expected that the user will be in the VR office environment for a long time, and much like how people pay attention to their homes and the interior design to make the place suit more to their tastes and create a personalized home, having these VR offices interiors designed solely for them is very important in their opinion. During the first interviews many people have said that things like changing a furniture's color, having a different kind of chair, having different curtains, basically overall having furniture and decoration more to their preferences and needs, would make their current office feel more welcoming and more for themselves. During the digital prototypes some users expressed that they would prefer other colors or other models of the used furniture assets, and when they were asked about the importance of the models and colors of the furniture one of the users that was testing the first office said "I would not be able to work with this desk. It looks nice but it is too big and makes me feel confined, and too dark for my tastes. If I got this chair in my current office I would ask for it to be changed, and if that will not be accepted I would ask for an office change". Not every person said they would have such

strong reactions to office assets not being to their preferences, however the ones that have complained indicated that this is a very big part of making the office 'their own'.

Second aspect of the environment in an office is the **location** of the office. This is more important with the outdoor offices, the people that have said they prefer an indoor office also wanted a view to their choosing. In the initial interviews, 17 out of 21 people that were interviewed have mentioned the location of their current office, in terms of view and feeling, either as a very positive or negative thing that affects their work and how they think of their offices greatly. Eight people said that the view out of their offices were really good, they enjoy and would want something similar in their other offices too in the future. These people had view of trees, mountains, sea, or a nice part of the city as a view. The nine people that did not like the view said that they wish the view was better or they would change their workplaces if it means getting a better view, and in this case they had view of very close tall buildings in general, and view of a factory in two of these cases. When some questions about the possible VR office that is customized for them, six out of eight people talked about outdoor offices they would want in specific locations and views. One user has mentioned in detail the kind of trees and flowers, and the color of the sea that is in his view, and another one talked about the details of the weather as an important aspect to feel like the environment is designed for her.

**Immersion** of the environment is very important in feeling of personalization. When the user feel immersed in the VR environment they can enjoy the privacy it brings. In the digital prototype testing, the users felt more relaxed and in control when no questions were being asked or some environmental sounds were being played. One user said "When I do not hear anyone outside I really feel like I am alone in this place (prototype 1, user Jay was based on). When I look over to the sea it really looks like the view from my summerhouse. Makes me feel much more relaxed. But when you eventually start asking questions I am pulled back here (his office)". The feeling of immersion helps the user to create their own personal space and makes people feel like they own the place since they can control everything. However one user has mentioned "The environment looking like as if it's completely real is making me focus more on the place and start looking around, which makes very distracted.", and in this case the feeling of control fades and people start feeling like on holiday as the feeling of being in an office disappears.

A supporting aspect to the immersion is the **sounds** in VR offices. The users did not think listening to desired music through headphones affected the feeling of personalization that much, but rather the natural sound effects such as the birds, rain, waterfall, leaves, or the absence of people chattering, printer sounds, keyboard clacking, made them feel like they actually are in a different place, a place that is built for themselves. Removing the chatter or the office sounds like keyboard clacks reduced the distraction greatly. During the usability testing of the second digital prototype, one user said "All these (office) sounds make me feel like I am still in my office. When you (tester) removed these sounds I took a big sigh of relief as I felt finally alone". Even though in general music was not considered to be an affect on

personalization, and in some usability tests for the digital prototypes it reduced the sense of immersion, when the source of music was moved to a speaker in VR office, the reactions from the users were changed. When the music was coming from a place inside the office rather than the headphones, the feeling of immersion got affected positively. One user during the testing of office two prototype said "Listening to the music I like in this huge office feels very much in control of what is going on. My coworkers would never listen to this music, but here I am blasting it in this room where no one can say anything". Hearing the desired music within the office increased the feeling of control for five out of eight testers, while the other three did not show any preference over music and one of them said "I do not care which music there is. As long as it is not fast and someone is not screaming, I am fine with whatever".

# 6
# Discussion

## 6.1 Process

The initial goal of this research was to find answers to two of the research questions. These questions are:

- *What are the important aspects that make people feel in control in a VR office environment?*
- *What aspects of a VR office environment are important in making people feel like the environment is personalized and made just for themselves?*

In order to find answers to these questions interviews and shadowing was done, and with the result of these prototype VR offices were done. In these VR offices personalization was focused, and later on using Oculus Rift with the integration of a real-world incorporation into the virtual reality method, such as the one that was being developed for BeachHead, was planned to handle social interactions. Further on introducing the usage of the Oculus Rift Controllers to fully control and manage the environment was planned, in order to create an augmented reality workspace experience for the users and get more in-depth findings about the users' feelings, understanding, and reaction to a fully personalized office. However, after the user tests of the GearVR prototypes of the VR offices, it was realized that the scope of the project was too big to handle in such a limited time by one person alone.

The offices were created for only three people. The aim was to create very simple virtual reality offices that have artifacts from the person's original real-life office, and put the necessary ones into a desired place in order to test the comfort the user has, how much they feel that the office is 'their own', and how suitable it would be for the user to work in such an environment. In order to create these offices many aspects of users were closely observed, in-depth interviewing about their personality and over 7 hours of continuous shadowing were done for each of the users, and these three people were already personally known and had close relationships with the researcher. After the first testing it became obvious that in order to achieve the initial goal, many more tests had to be done, but more importantly many of the users' habits, desires, and maybe even the actions they themselves do not realize doing had to be observed and understood, in order to create the fully personalized working VR office. This can be done for three or five people, but in the future if this kind of usage of VR offices were to be commercialized it would not be feasible for a designer to do all of these for every single client, and even if this happened it would be way too expensive for a regular person to use. Therefore, a standardization

of creation of the offices is necessary while maintaining the personalized feeling of the offices. Designing a tool for creation of personalized office that can be used by the designers closely with the users would help not spending too much time with the observation of user, and trying and testing many different iterations of the office.

The results of two iterations of researching, prototyping, and testing of the created simple VR offices were used in the designing of the office creation tool and in this way the process of this thesis overall followed a Research Through Design approach. With changing the goal from creating detailed augmented reality offices to designing personalized virtual reality office creation tool, new planning had to be done. Additional brainstorming to decide what kind of tool can be created and what properties it can have was done, and along with the brainstorming many sketches were done in order to realize these properties and further on improve on them. At this point, the main problem was the lack of time in the project, and because of this rather than having many small prototypes and user tests, and multiple iterations to strengthen the design, having one in-depth paper prototype, and further on a digital prototype was decided on. Even though multiple iterations and many tests are more desirable in a design process, the time restrictions led to this decision, since every single iteration would take some time for it needs usability tests, and instead of spending time on small properties, the prototype was tried to be developed as much as possible in order to see many problems at once. Unfortunately, because of the lack of time, further testing with high fidelity digital prototypes could not be done.

## 6.2 Result

### 6.2.1 Office Worker Types

With the results of the interviews, observations, and shadowing, it is found that not all types of office workers might be suitable for virtual reality offices. Some types of office workers, such as Filers, require lots of social interactions with people that are outside of their company, and these interactions usually last for a short time, which makes it uncomfortable for the other party to see the Filers wearing a VR Headset while talking to them, therefore the social interactions were not included in the further research and design of this project. Filers also have to deal with physical materials and have small social interactions with their coworkers very often, and integrating of real-world images and manipulating the VR environment with hands should be done in order for this type of office workers to be able to use such VR office effectively. Organizers, in addition to having many small social interactions like phone calls, require a lot of physical movement, which led to the decision of leaving Organizers out of the research and design of this project for now.

### 6.2.2 Usability Testing for VR Office Prototypes

#### 6.2.2.1 First Office - Jay's

Apart from the person that Jay was inspired by, not much positive response was received. The first person tested thought that it is great for an office; he could do everything he needed to do in that, and the most important thing for a CEO is to communicate with people well, and relax and reduce their stress during the small free time they have during the day, and this accomplishes that. Overall finding from this office's testing showed that people have completely different habits and opinions about different work styles and places. The office itself was personalized for one person, and that person enjoyed the office a lot, however the fact that the other people did not like it shows that personalization of such VR offices is very important.

#### 6.2.2.2 Second Office - Jordan's

People thought it is nice for an office, it helps focusing, it is roomy and fresh. Need to find a way to let the user know that another person is close. The testers did not want visual feedback for that. Even though the first user and the second user work at the same place and the VR office can be applicable for both, they reacted completely differently. The second tester wanted much cozier and more colourful place while the first tester preferred to keep everything out of the VR office that will not be used. These tests also showed that some people are not suitable for such VR offices, as every comment second user made about the office led to her saying that the real office is better. She preferred constant human interaction, she preferred the feeling an active office gives her. Maybe if this person were to be the one of the people that the offices were built for, some characteristics about the person and her desired office could be found and the created VR office might be an improvement for her, but for now nothing can be said about what type of VR office would suit her. This led to the finding that every single person needs in depth research about themselves and their office usage in order to create a personalized VR office, because sometime they themselves do not know what is suitable for them.

#### 6.2.2.3 Third Office - Taylor's

In these tests the main problem was managing the input to the computer. Having some gestures to switch through the applications might be good, however if the users needs to code a lot it becomes a problem. With normal writing, speech to text is a valid solution that is easily implementable, however when different coding languages are introduced things become a bit more complicated. Having a speech to text program that understands the coding language said out loud without saying

words such as 'squiggly brackets' or 'semi colon' at the end of every line might be a solution to this, however even such signs are not said out loud, the speed comparison between writing the code and speaking the code should be made. If the keyboard is chosen as the input device, then seeing the keyboard and seeing the hands should be managed, which also results with users not being able to hold controllers. In offices like this, that require lots of constant interactions with keyboards, hand and finger gestures should be the main way of interacting with the environment. This finding led to further testing of the VR offices, this time focusing on the gesture usage and how comfortable the users feel about them.

### 6.2.3 Usability Testing for Paper Prototype

A question that was considered throughout the project as a supporting idea, was *How can an application be used to create personalized VR/AR offices using standardized assets?*. This was focused over the course of the Design phase of this thesis, and the aim of the usability testing for VR office prototypes was to mainly to find answer to this question.

An application that asks the user for office preferences and in turn creates a virtual reality office using the preset assets can be created. A thorough scanning of the office is necessary for the application to include the assets within the office properly. One possible way to do this is using the 3D scanning device Structure along with the home improvement application Canvas that can digitalize a room, and creating a completely scanned office to use in the VR office creation tool[3][35]. With the scanned room, the application easily uses the items within the room to bring those to the one of the preset locations that the user has chosen. Every aspect of the virtual reality office is chosen from previously designed items, and further manipulation of such items can be done if the user desires so. With the help of a designer, more personalization of the office can be done if needed. The process was well liked by the tested users, and standardization of creating personalized offices is quite feasible.

### 6.2.4 Findings

The initial aim was to find answers to the following questions with researching through designing:

- *What are the important aspects that make people feel in control in a VR office environment?*
- *What aspects of a VR office environment are important in making people feel like the environment is personalized and made just for themselves?*

However during the progression of this thesis the scope was realized to be too big to handle in this limited amount of time with one person, therefore the aim of the

thesis has changed. With the new goal in mind, the first question was scrapped and discontinued to search an answer for, and the following question was asked:

- *What aspects of a VR office environment are important in making people feel like the environment is personalized and made just for themselves?*

Considering the effects of **environment** of the workplace on an office worker, finding that the environment and its manipulation being the most important aspect in personalization in VR offices was expected. However, immersion was not considered to be a major aspect before the results were seen. The effect of presence of bird sounds were bigger than the presence of the birds themselves in the first office; the users did not even try to see where the bird sounds were coming from, they just said it makes them feel more like they actually are in the VR office. Although more than the positive effects of increased immersion, negative effects of very high immersion was more important. Depending on the user, feeling as if they really are in the location of their choosing might not be the best; if the user tends to get the feeling of vacation in the environment they want for their VR office, some ways to not let the user be completely immersed in the environment should be considered, such as keeping some of the office sounds in the background, or not using hyper realistic assets in the creation of the location.

## 6.3 Additional Considerations

The results gotten with GearVR provide a good basis for Oculus Rift or HTC Vive implementations. In GearVR, it is only possible to use a one-handed controller that has rotation tracking, however it cannot track motion. Usage of a full VR device will enable motion tracking and will make the environment feel easier to control. Ideally using hand tracking for gesture recognition would provide better results to show gesture preferences and the comfort the users have, however implementing motion tracking was not possible due to time constraints, therefore small interviews on gesture preferences were done without any gesture recognition. Testing the manipulation of the environment and various objects was also considered, however this also required motion tracking, which was not implemented.

Handling social interactions is a major part of virtual/augmented reality offices, and how they are handled is very important in personalization, as every person might have different preferences with the amount and the extent of social interactions they would want while using their offices. This was talked about with the users during interviews and tests in order to understand what different people might want, however due to technical limitations implementing real-time rendering of people in real world into the virtual reality environment was not possible, as this is something that is still being researched and developed in projects like *BeachHead*[31]. During the tests, some possible social interactions were considered, for example the user was

asked to interact with their coworker - which was essentially a point cloud in the shape of a person sitting in front of their desks - to see how real the users would perceive them or how the users would choose to interact with a person that is not wearing a VR headset, however major social interactions like talking are avoided completely, as the rendering of the person in VR environment was not possible.

Another very important consideration with personalization of the virtual reality offices is the handling of the incoming notifications. These notifications can be things like a phone call, an e-mail, or a knock on the door. All of these should be notified to the user without disturbing their work and in a way that will be noticeable. Such notifications should follow the calm technology guidelines and the user should choose how they will be represented as in order to create the personalized VR office that will be suitable to work in[45]. This was one of the major focuses of the initial project mentioned at the beginning, however was decided not to be further investigated in this project.

The concept of VR and AR offices is based upon people using this technology multiple hours a day, five days a week. Since it is assumed that the users will be involved with these offices for a very long time, long term effects are important to consider. Currently, we can only assume some drawbacks of such usage however with the scope of this project no research that can show the effects of long time usage could be done, and this is a very important aspect to research as soon as possible.

## 6.4 Future Work

The time limitation and the solitary work of this thesis forced the work to be much narrower that it was planned to be, and the project had to be cut short before a final design could be made. In order to reach a final design, few iterations of possible digital prototype, and many usability testings of the design are necessary. Throughout this thesis, the lack of people interviewed and tested has been touched upon too. The initial observation required many different places, and interviews were tried to be done with different types of office workers, and the virtual reality office tests were done with very limited amount of people, so the number is still quite low to have reliable findings for a commercialized design. Further investigation of what people would want or not want in their virtual reality offices is necessary in order to widen the setting of the personalized virtual office design tool. Furthermore, the design should be tested with other designers, who might eventually be the main users of this design, as the people during the usability tests have indicated that the help of a more knowledged person would be essential for further personalization apart from the setup process, and some people have mentioned that they would rather hire a professional to do this and work very closely with them in order to get the most out of a virtual reality office.

Creating a tool to design and change the office within the office environment in headset is a possible implementation to consider for this project. Changing and

manipulating the objects within 3D virtual world and changing the settings and possible locations as if using a brush to draw a new environment like in Google's *Tilt Brush*, would allow user to see the results immediately, therefore will create more precise and desirable offices[39].

Implementing hand tracking in GearVR with the combination of VRRidge, Leap Motion with Orion, and Steam driver for Leap Motion is a possible way to conduct more in-depth tests for environmental controls within the virtual reality office[44][30][9]. Another possible way to do this is to use NanoMotion, a hand tracking SDK that uses smartphone camera and can recognize gestures in real time [16]. Usage of NanoMotion will further on enable the testing in augmented reality, therefore it would be much more preferable. Testing the gestures in GearVR and implementing similar usage in Oculus Rift of HTC Vive will give the chance to test and compare the usage and the possibilities of both full VR and smartphone-based VR. This is important to choose the optimal device to implement such offices as both have pro's and con's, the most major one being full VR devices having to be connected to a computer while GearVR is a standalone device.

Researching more about the office worker types might lead to a discovery that will make the designing of the virtual reality office process much easier. People belonging to different types have certain actions they always do and they have different amount of social interactions with different kinds of people. Considering these properties, some more preset properties can be made for the office creation. A previously mentioned hypothesis is that the same office work types have similar character traits, which might standardize the creation of the virtual reality office process even further. Having a more thorough research about the worker types with more participants might show different types, and again, it might help with adding more properties and creating certain settings suitable for different types which in turn will be useful in the virtual reality office design tool.

# 7
# Conclusion

The purpose of this thesis was to find the properties in a virtual reality office that make people feel like the office is their own, and to design an application that can have standardized assets from these properties, and to use them to create a personalized virtual reality office for the users.

At the beginning, naturalistic observation was done in people's natural working environment, and some interviews were conducted in order to understand how people would want to use VR offices, and what aspects are important to them. With these findings, shadowing on 4 people was done in order to get in depth information about their working habits. Three of these people were further on used in order to create virtual reality offices they would want to see, and test the usage of these offices.

With the results from these office testings, sketches and prototypes were done along with further interviews, to design the personalized virtual reality office tool. A paper prototype of this tool was created to test the usability.

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